Lesson 5: Precipitation Algorithms and Products

Overview

This lesson will present the precipitation products generated by the WSR-88D, and the algorithms which produce them. The lecture and supplementary material will give the student detailed information about each of the algorithms. This material can be used in preparation for the post cursor test given to NWS personnel at some point after they return to their duty station.

It is important for WSR-88D operators to know the algorithms and how they affect the precipitation products currently available in the WSR-88D. This is true not only for NWS personnel, but also for DOD personnel, as rainfall amounts can affect both civil and defense operations.

Class Lecture

Algorithms

Products

Case Studies

Lesson Review

Student Guide

Lecture Material

Review Exercise

Supplemental Information, with an emphasis on adaptable parameters

References

FMH 11 Part C; pages 2-45, 2-77, 2-83, 2-85, 3-6 thru 3-17

Objectives

1. Given WSR-88D precipitation products and rain gage reports, you will be able to determine if the WSR-88D precipitation estimates are reliable.

2. Given WSR-88D precipitation products, rain gage reports, and flash flood guidance, you will be able to determine if flash flooding is likely to occur, and identify the county location.

3. Given simulated real-time WSR-88D data, synoptic reports and analyses, and observer reports, you will be able to determine whether precipitation estimates are reliable. (PUP Lab only)

4. Without references, in accordance with standardized instruction, you will be able to:

a. Identify the strengths and limitations of the Precipitation Processing Subsystem.

b. Describe the precipitation products produced by the Precipitation Processing Subsystem.

c. Identify the applications and limitations of the Precipitation products.

Precipitation Products Users and Benefits

NWS Hydrology Program

Real-time rainfall estimates of long or short duration available over large areas

NWS Meteorology Program

Real-time hourly rainfall estimates available over large or small areas

Other Users

Corps of Engineers for water management, local flood control districts, military operations and logistics

Precipitation Algorithms Section

Overview

Precipitation Detection Function

Rain Gage Data Acquisition Function

Precipitation Processing Subsystem

1. Preprocessing

2. Rate

3. Accumulation

4. Adjustment

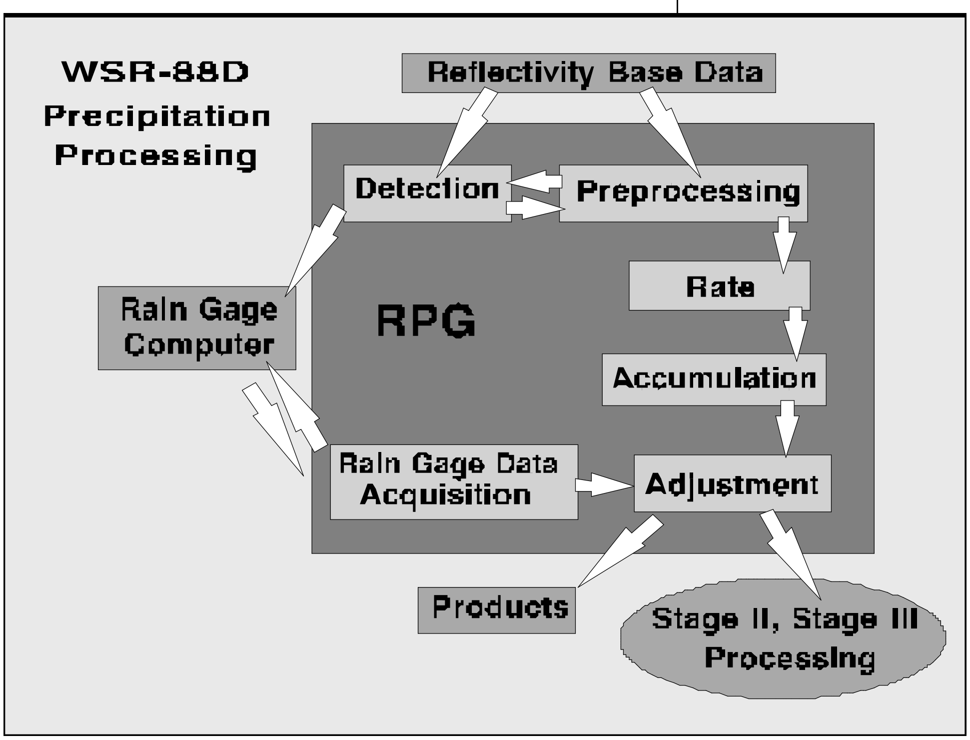


Figure 8-21. WSR-88D Precipitation Processing

Products Produced by WSR-88D - Algorithm Results

Graphical and Alphanumeric Products at the PUP

1. One Hour Precipitation

2. Three Hour Precipitation

3. Storm Total Precipitation

4. User Selectable Precipitation

Alphanumeric Product at the PUP

1. Supplemental Precipitation Date

Digital Product output to RFCs/WFOs

1. One Hour Digital Precipitation Array

Precipitation Detection Function

See Supplementary Material 8-5-1 for information on the adaptable parameters in the Precipitation Detection Function

The main purpose is to determine if precipitation is occurring within 124 nm of the radar.

Base Reflectivity Data lowest 4 slices examined

Thresholds Exceeded?

Precipitation Rate Threshold (echo intensity, in units of rainfall rate)

Precipitation Area Threshold (in km^2)

Nominal Clutter Area Threshold (in km^2)

Each volume scan, intensity and areal coverage of the reflectivity data (lowest 4 slices), is compared to these thresholds. In order for the algorithms to begin accumulating nonzero precipitation, the intensity and areal coverage must equal or exceed the Precipitation Rate Threshold, ***and*** Area Threshold (the ***sum*** of the Precipitation Area Threshold and Nominal Clutter Area).

While all three parameters are adaptable, the Precipitation Rate and Area Thresholds are OSF controlled, while the Nominal Clutter Area Threshold is URC controlled.

Category Detection vs Assignment

A category ***detection*** means that the rate and areal coverage thresholds for that category have been equalled or exceeded for the current volume scan. It does not necessarily mean that the particular category has been ***assigned***. For any particular volume scan, the category that is assigned will control which VCP may be available.

Precipitation Categories Assigned

Each volume scan, a precipitation category number is ***assigned***.

Category 0

No precipitation has been detected within 124 nm of the RDA in the past hour. No thresholds are met or exceeded. Once category 0 has been ***assigned***:

VCP Changes

1. If the WSR-88D is in a Clear Air Mode VCP, it will remain there.
2. If the WSR-88D is in a Precipitation Mode VCP, it can be manually switched back to a Clear Air Mode VCP.

Note that since category 0 is defined as no precipitation in the past hour, one hour will elapse from the time that category 0 is ***detected*** to the time that it is ***assigned***. Once category 0 is assigned, as far as the Precipitation Processing Subsystem is concerned, it's not raining, so the algorithms will be accumulating zeros.

Category 1

Significant precipitation has been detected within 124 nm of the RDA in the past hour. Significant precipitation may include high precipitation intensities over small areas or low precipitation intensities over large areas. The rainfall is significant from a hydrologic standpoint, where accounting for water in the soil and on the surface becomes important.

Category 1 Thresholds

The thresholds for category 1 are:

- Precipitation Rate Threshold of 4 dBR = 30 dBZ
- Threshold Area is the sum of the Precipitation Area Threshold of 10 km^2 and the Nominal Clutter Area

VCP Changes

When the category 1 thresholds are equalled or exceeded, then category 1 is assigned. For the volume scan where category 1 is ***initially assigned***, there are two possible outcomes:

1. If the WSR-88D is in a Precipitation Mode VCP, the precipitaiton algorithms will be executed, and the radar will stay in its current VCP.
2. If the WSR-88D is in a Clear Air Mode VCP, a VCP restart with an automatic switch to VCP 21 occurs, and the precipitation algoriothms are executed.

Note that since category 1 is defined as significant precipitation in the past hour, category 1 will continue to be ***assigned*** for up to one hour after it is no longer ***detected***.

Category 2

Light precipitation is detected within 124 nm of the RDA in the past hour. This may include isolated very weak convection or low intensity widespread events.

Category 2 Thresholds

The thresholds for category 2 are:

- Precipitation Rate Threshold of -2 dBR = 22 dBZ
- Threshold Area is the sum of the Precipitation Area Threshold of 20 km^2 and the Nominal Clutter Area

```
                         PRECIPITATION DETECTION                    PAGE  1 OF  1
COMMAND: AD,*****,M,*****,P,
FEEDBACK:                                                                OPER A/21

      (M)odify, {LINE#}   (E)nd     (C)ancel   (D)elete, {LINE#}
```

N	Tilt Domain		Precip Rate Thresh (dBR)	Nominal Clutter Area (Km2)	Precip Area Thresh (Km2)	Precip Cat.
		-				
1	0.0	2.0	-2.0	80	20	2
2	0.0	4.0	4.0	80	10	1
3	2.0	4.0	-2.0	80	20	2

Figure 8-22. Precipitation Detection Function screen. The Nominal Clutter Area should be used to account for the areal coverage of residual clutter.

VCP Changes

For volume scans where category 2 is ***assigned***, there is no automatic VCP change, and the algorithms are executed. Category 2 allows accumulations in any VCP, including the Clear Air Mode VCPs.

Note that since category 2 is defined as light precipitation in the past hour, category 2 will continue to be ***assigned*** for up to one hour once neither category 1 or 2 are no longer ***detected***.

Category changes as the event dissipates

Category 1 supersedes category 2, and will continue to be ***assigned*** for one hour ***after*** the category 1 thresholds have been met or exceeded.

Category 1 to category 2

In this case, conditions downgrade to below category 1 thresholds, with category 2 ***detected***. After one hour, category 2 will be ***assigned***. Once category 2 is assigned, the UCP operator may switch to ***any*** desired VCP.

Category 1 to category 0

In this case, an event downgrades from a category 1 assignment to conditions below ***both*** category 1 ***and*** 2 thresholds. Category 1 would still be assigned for one hour, then category 0 would be assigned. Once category 0 is assigned, the UCP operator may switch back to a Clear Air Mode VCP.

Clear Air and Precipitation Detection

At times, such as a snow event, Clear Air mode reflectivity data may be desired. VCPs 31 or 32 will display the lower reflectivities down to -28 dBZ. By raising the Nominal Clutter Area for only Category 1, and leaving the Nominal Clutter Area low for Category 2, precipitation thresholds (Rate and Area) will be exceeded for Category 2, but the thresholds (Rate and Area) will not be exceeded for Category 1. Since the thresholds for Category 2 and not Category 1 have been exceeded, the precipitation is considered by the radar to be Category 2. The radar can be run in VCPs 31 or 32, display lower reflectivities, and still generate precipitation products.

In the following event (See Fig. 8-23 and Fig. 8-24), convection occurred in the afternoon and evening with a frontal passage and transition to snow the following morning. Note that the radar is in Clear Air mode during the snow portion of the event. Also note that the Storm Total Precipitation product shows that accumulations continued even after the switch back to Clear Air Mode. This switch could only have occurred because of the assignment of category 2.

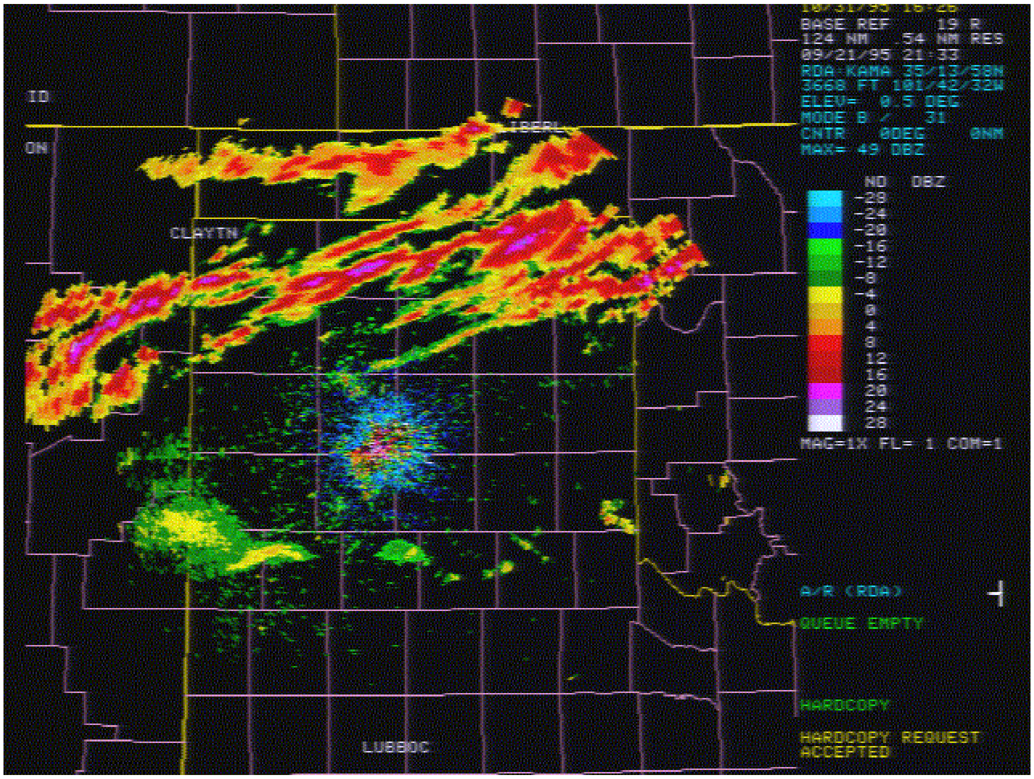


Figure 8-23. Base Reflectivity product (Clear Air Mode) with snow bands. Convection had occurred the evening before, thus the radar had been in Precipitation Mode.

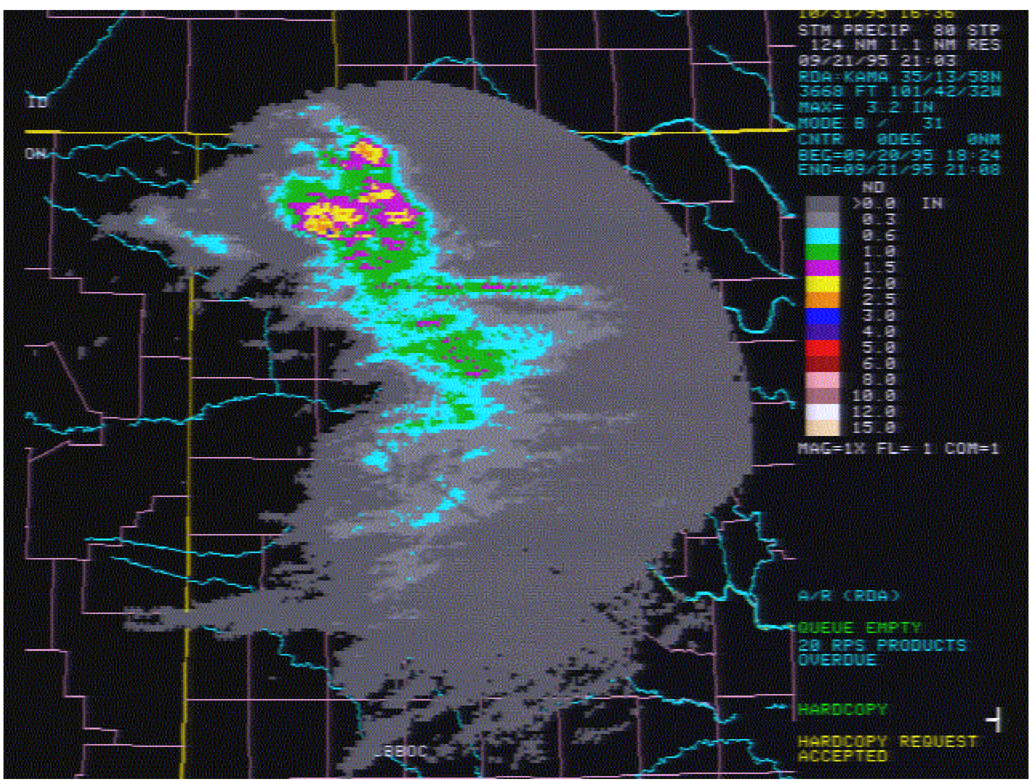


Figure 8-24. Storm Total Precipitation. Note that the beginning and end times include both the convection and the snow. Thus the switch back to Clear Air Mode occurred due to the assignment of category 2.

This method may be advantageous when trying to detect boundaries within your county warning area, and precipitation may be occurring outside your county warning area. This will allow you to keep the radar in a more sensitive VCP, while precipitation products will still be generated for other users, such as River Forecast Centers.

Word of Warning

This method must be used with care however. The potential exists for significant storms to develop, without the automatic switch to VCP 21. If storms exceed the reflectivity threshold for Category 1, the radar will not automatically switch to VCP 21 unless the areal coverage is also satisfied. It is therefore critical that the nominal clutter area is one of the parameters that is checked when beginning each shift.

Raising both Category 1 and Category 2 nominal clutter areas is not the proper way to keep the radar out of Mode A during Anomalous Propagation. The base data will still be contaminated by the AP unless it is suppressed at the RDA. If returns due to AP are causing the radar to exceed Category 1 or Category 2 thresholds, then invoking a Clutter Suppression Region at the UCP is the appropriate way to mitigate that problem.

Precipitation Detection Status Screen

The Precipitation Detection Status Screen at the UCP contains information relating to the Precipitation Detection Function. The following information may be found on the first page. See Fig. 8-25.

1. On the first line of page 1, the currently assigned precipitation category is listed. The UCP operator may refer to this line when making VCP changes. If the assigned precipitation category is 0 or 2, any VCP may be invoked. If the assigned precipitation category is 1, a precipitation mode VCP is required.

2. The next line displays the threshold information pertaining to the category currently being ***detected***. The detected area can be compared to the threshold area to determine an appropriate setting for the nominal clutter area. At the end of this line the category that is currently ***detected*** is displayed. Note that the detected category may not be the same as the assigned precipitation category found on line 1.

3. The final three lines contain information on when precipitation categories 1 and 2 were last detected. If category 1 is assigned, but no longer detected, the time left in category 1 indicates when category 0 or 2 will be assigned. When the time left in category 1 counts down to zero, a switch to a Clear Air Mode VCP will be allowed.

```
                         PRECIPITATION DETECTION STATUS            PAGE  1 OF  2
COMMAND: ST,PRE
FEEDBACK:                                                             OPER A/21

------------------------------------------------------------------------------
ASSIGNED PRECIPITATION CATEGORY                 1 - SIGNIFICANT PRECIPITATION
------------------------------------------------------------------------------

ELEV    RATE (dBR)    REFL (dBZ)     THRESH         DETECTED       DETECTED
ANGLE   THRESH        THRESH         AREA (km2)     AREA (km2)     PRECIP CAT
------------------------------------------------------------------------------
0.5      4.0           30.4           90             2075               1
------------------------------------------------------------------------------

       EVENTS                      DATE        TIME      TIME LEFT IN CAT 1
------------------------------------------------------------------------------
CAT 1 PRECIP LAST DETECTED        7/15/96      18:12        01:00:00
CAT 2 PRECIP LAST DETECTED        7/15/96      18:12
DETECTION FUNCTION EXECUTED       7/15/96      18:12
------------------------------------------------------------------------------
NOTES:  AREA THRESH      = NOMINAL CLUTTER + PRECIP AREA
```

Figure 8-25. First page of the Precipitation Status Screen.

The second page of the Precipitation Status Screen displays the elevation by elevation output of the Precipitation Detection Function. See Fig. 8-26.

1. Since category 1 has precedence, each of the lowest four elevation angles is searched for category 1. As soon as category 1 is detected for a particular angle, the search is terminated. The threshold information for that angle will be displayed on page 1 of the Status Screen.
2. If category 1 is not detected for any of the angles, but category 2 has been, then that volume scan will show a category 2 detection. The threshold information for the lowest angle where category 2 was detected will be displayed on page 1 of the Status Screen.

```
                       PRECIPITATION DETECTION STATUS            PAGE  2 OF  2
COMMAND: ST,PRE
FEEDBACK:                                                                OPER A/21

-------------------------------------------------------------------------------
ELEV      RATE (dBR)  REFL (dBZ)  THRESH      DETECTED     PRECIP        CATEGORY
ANGLE     THRESH      THRESH      AREA (km2)  AREA (km2)   CATEGORY      CRITERIA
                                                                         SATISFIED
-------------------------------------------------------------------------------
0.5        -2.0        22.0        100          3467         2              YES
0.5         4.0        30.4         90          2075         1              YES




-------------------------------------------------------------------------------
NOTES:    AREA THRESH = NOMINAL CLUTTER + PRECIP AREA
```

Figure 8-26. Second page of the Precipitation Detection Status Screen

Once Category 1 or 2 is assigned

1. Rain Gage Data Acquisition Function is activated

2. Complete run of precipitation processing algorithms

Gage Data Support System

This software, which resides in the RPG, accesses an external computer system with a rain gage data base.

The Precipitation Detection Function will activate an external computer (eventually AWIPS). If category 1 or 2 is detected, the external computer will access hourly rainfall from gages within 124 nm of the RDA. Any current rainfall reports are transmitted to the RPG for adjustment of radar estimates

The hourly rainfall at the gages will then be transmitted, in SHEF (Standard Hydrometeorological Exchange Format), to the Rain Gage Data Acquisition Function located at the RPG. The Rain Gage Data Acquisition Function maintains a data base of precipitation gage reports which are used as ground truth by the Adjustment Algorithm (discussed later).

Complete run of precipitation processing algorithms

The Precipitation Detection Function also initiates the Precipitation Processing Subsystem (PPS), consisting of four algorithms which contain numerous quality control steps. Since radar only indirectly measures precipitation rates, extensive quality control is applied to get the best possible rainfall estimates. The four algorithms are:

Precipitation Preprocessing Algorithm

Precipitation Rate Algorithm

Precipitation Accumulation Algorithm

Precipitation Adjustment Algorithm

Because of the quality control steps used in these algorithms, the operator will notice a difference between the reflectivity data used as input and the corresponding precipitation products.

The PPS provides rainfall estimates out to 124 nm. No estimates are generated beyond 124 nm because errors increase rapidly beyond that range.

The algorithms in the PPS are highly flexible with many adaptable parameters. The process of tailoring adaptable parameters for each radar site requires research and observations from the field users of the system. When it is determined that adaptable parameter changes are needed, approval through the OSF and the Office of Hydrology will be necessary.

Precipitation Preprocessing Algorithm

See Supplementary Material 8-5-2 for information on the adaptable parameters in the Precipitation Preprocessing Algorithm.

The Precipitation Preprocessing Algorithm uses base reflectivity from the four lowest elevation angles as input (regardless of VCP) This algorithm begins to execute at the end of the fourth elevation scan.

There are five quality control checks used on the base reflectivity data in order to get the best reflectivity values to build a sectorized hybrid scan (1^0 x 0.54 nm sample volume).

Base Reflectivity Data Quality Control

Designed to correct problems due to

1. Radar Beam Blockage

2. Spurious Noise

3. Reflectivity Outliers

4. Ground Returns

5. Change in Beam Height with Range

For radials with blockage of no more than 60%, dBZs added to range bins beyond obstacle

Radar Beam Blockage (Fig. 8-27)

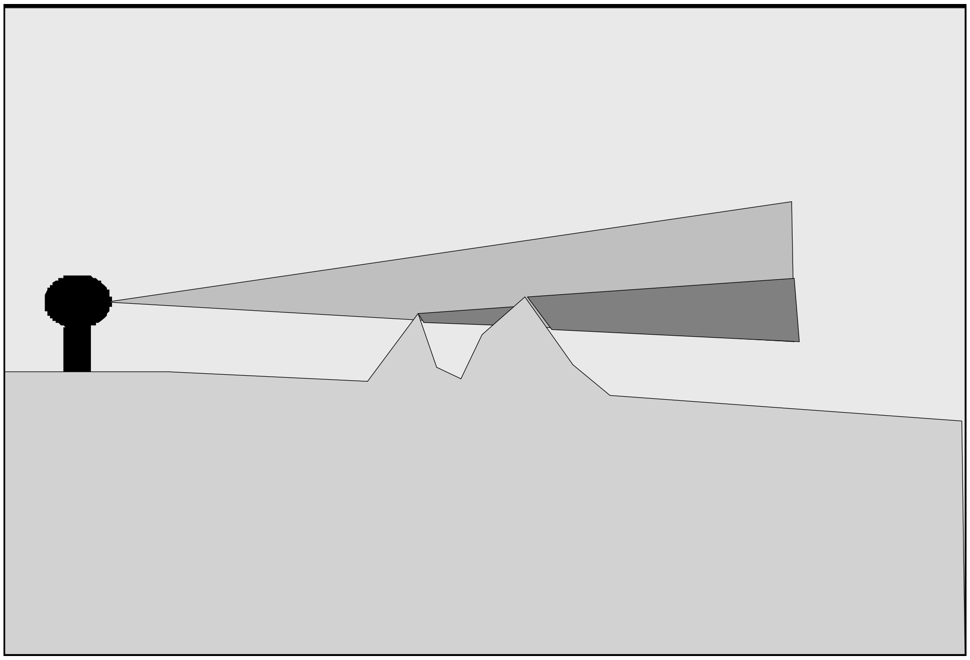


Figure 8-27. Radar Beam Blockage

The first quality control step corrects for physical blockage of the radar beam. Precipitation underestimation will result otherwise. If the radar beam is blocked by 60% or less a predetermined dBZ value is added to each sample volume that is partially blocked.

If more than 60% of the beam is blocked then one of two actions is taken. If the blockage is 2^o or less in azimuth, the average value of the range bins next to the blockage, in that elevation angle, is assigned to the blocked sample volumes. If the blockage is greater than 2^o in azimuth, then no correction is made. For that sector, values from the next highest elevation angle would be used.

See Supplementary Material 8-5-7 for additional information on the Beam Blockage Step.

Spurious Noise and Outliers

Although point clutter suppression has been applied at the RDA, more quality control is necessary.

The second and third quality control steps in the Preprocessing algorithm correct unrealistically high reflectivity values. These may be due to false returns caused by system noise or isolated targets such as airplanes, or by contamination from hail. These reflectivities are of two types, isolated reflectivities and reflectivity outliers.

Isolated Reflectivities

The second quality control step searches for and corrects isolated reflectivities. An isolated reflectivity is a value that indicates precipitation, but the range bin is in an area of non-precipitable returns. This may be caused by spurious noise or an airplane flying through the beam. A reflectivity value is considered isolated by the algorithm if:

The reflectivity value is greater than a low minimum threshold (MNRFL, currently 18 dBZ) and

0 or 1 of the neighboring values are greater than MNRFL

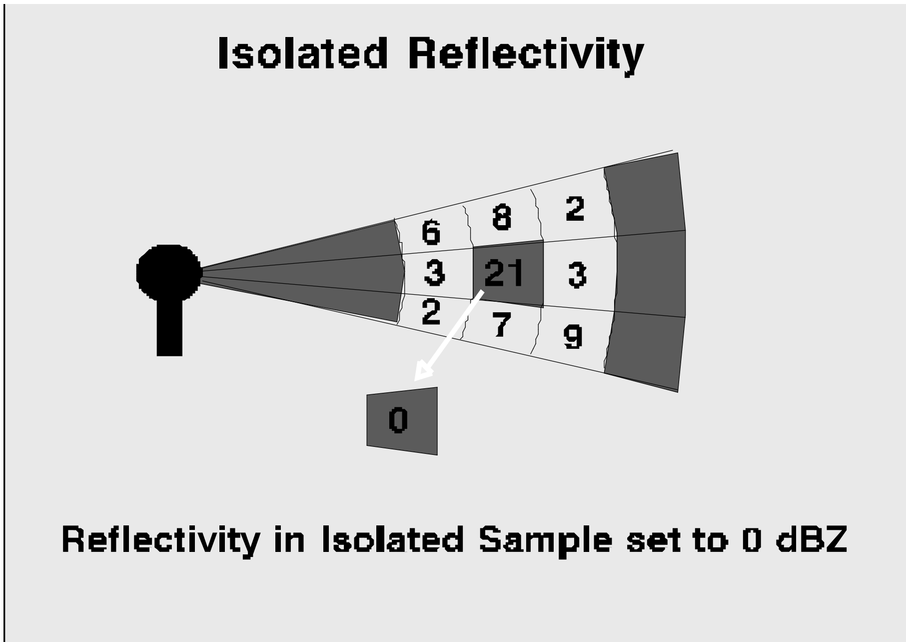


Figure 8-28. Isolated reflectivity and its reset value.

Once a reflectivity value is flagged as isolated, it is set to zero dBZ. See Fig. 8-28.

Reflectivity Outliers

The third quality control step removes reflectivity outliers that can cause precipitation overestimation. An outlier is defined as a range bin which contains a dBZ value within an area of precipitable returns that is greater than is reasonably expected to occur. A range bin is flagged as an outlier if its reflectivity value exceeds the current outlier threshold (MXRFL, 65 dBZ).

The outlier will be corrected one of two ways, depending on the value of its neighbors.

First possibility

If all eight neighboring range bins have values below MXRFL, the outlier is replaced by the average of the eight neighbors. See Fig. 8-29.

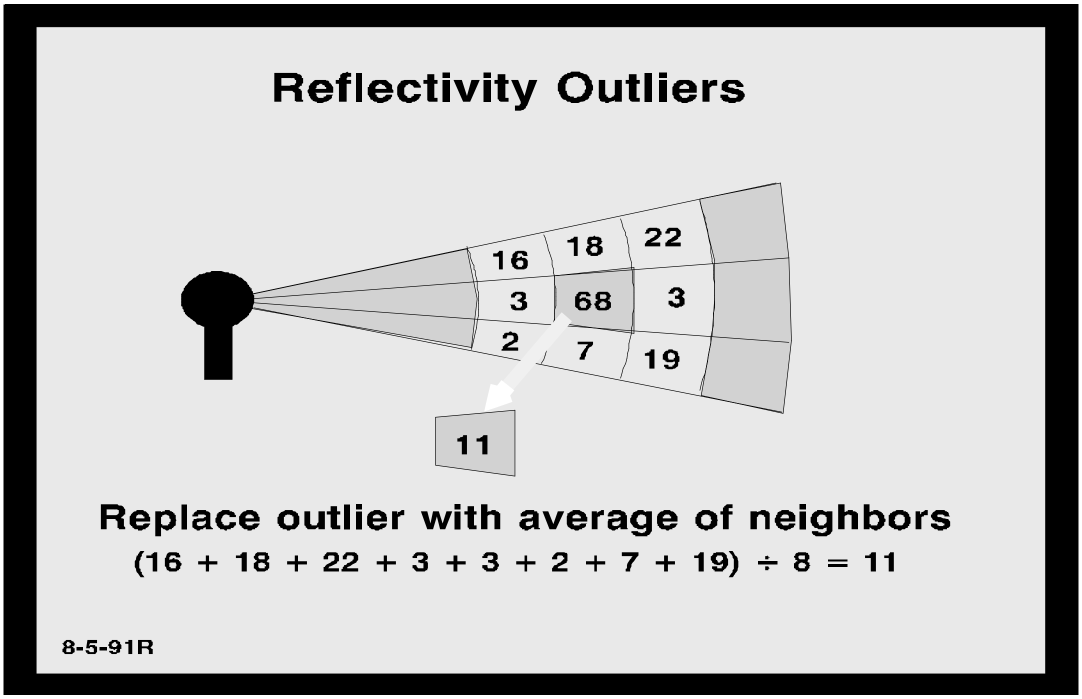


Figure 8-29. Reflectivity outlier with all eight neighbors below MXRFL.

Second possibility

If one of the surrounding neighbors also contains an outlier, the range bin is set to a low dBZ value (7 dBZ). The outlier step is designed to eliminate unrealistically high reflectivities, most likely due to hail contamination.See Fig. 8-30

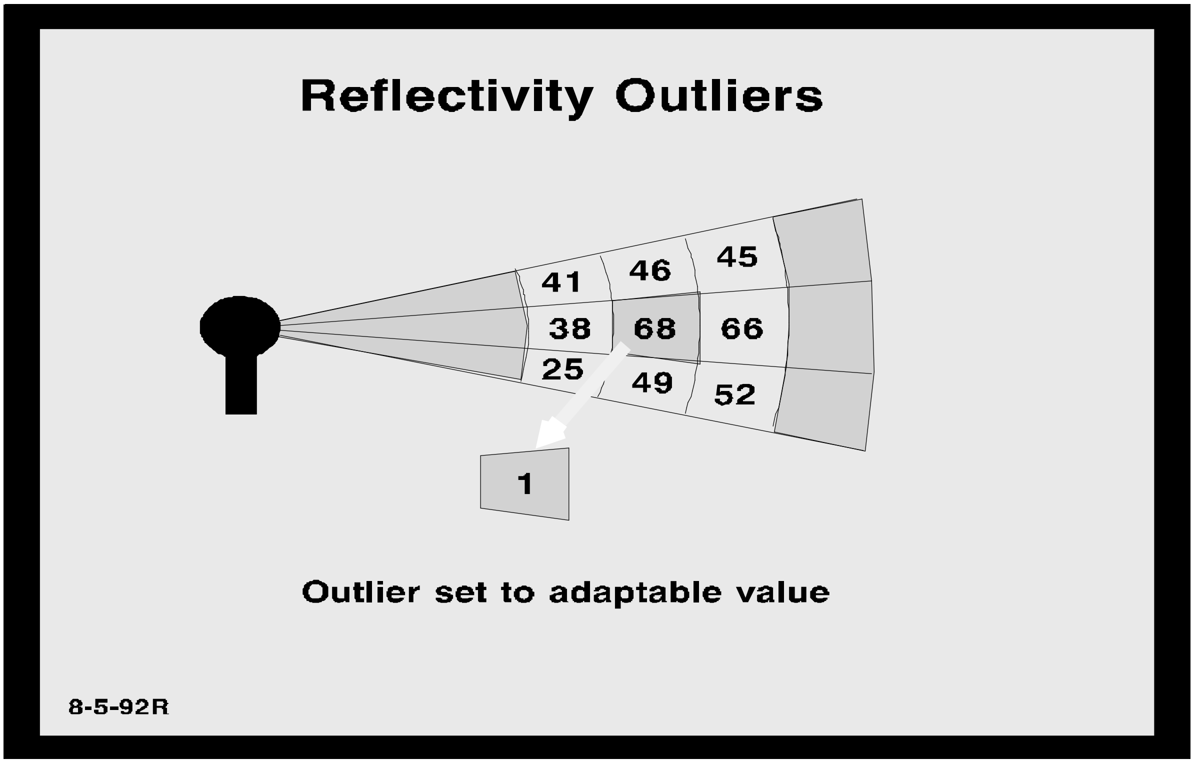


Figure 8-30. Reflectivity outlier with one of the neighbors also above MXRFL.

.Ground Returns/Tilt Test

The fourth quality control step removes normal and abnormal ground clutter returns caused by anomalous propagation. Although Clutter Suppression is applied at the RDA, more quality control is performed in an attempt to remove any residual clutter or clutter that has not been suppressed.

The algorithm checks each volume scan to determine if a given percentage of an echo disappears from the lowest elevation angle to the next highest elevation angle. This is called the tilt test.

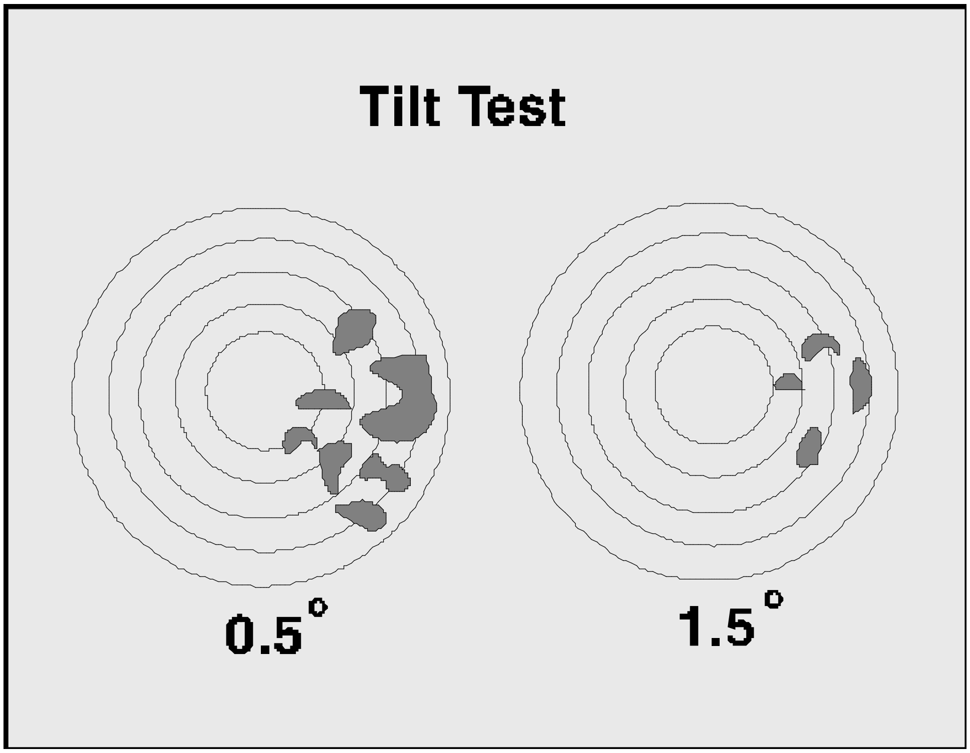


Figure 8-31. Tilt Test

Currently, the percent reduction is set at 75%, but is adaptable. It may be set at a value between 25% and 100% with OSF approval. If 75% or more of the echo disappears from the lowest elevation angle to the next highest, the return from the lowest elevation angle is not considered to be precipitation and is no longer used in precipitation processing.

Change in Beam Height with Range

Hybrid Scan Construction

The last quality control step tries to correct for the changes in beam height with range, with the objective of sampling as uniform a height above ground as possible. The result is the sectorized hybrid scan, using reflectivity data at an altitude as close to 3000 ft. AGL as possible using a combination of the 4 lowest elevation angles.

Default Hybrid Scan

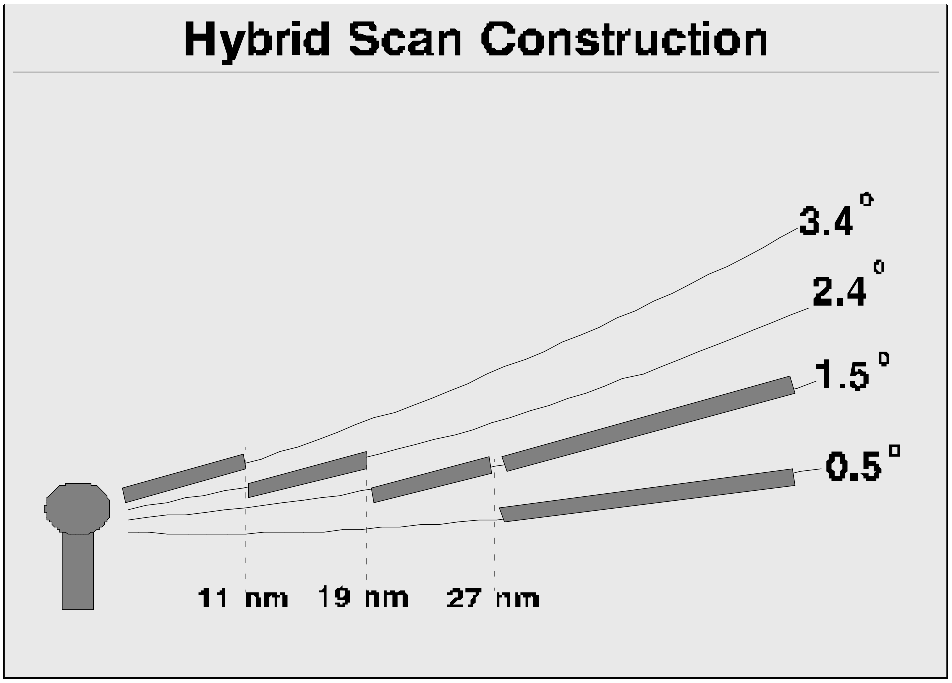


Figure 8-32. Default Hybrid Scan Construction

For radials without significant beam blockage, reflectivity from 3.4^o is used from 1 to 11 nm from the RDA, while data from 2.4^o is used from 11 to 19 nm. The 1.5^o angle is used for the 19 to 27 nm range. Beyond 27 nm, either the 0.5^o or the 1.5^o angle is used. See the discussion on Bi-Scan Maximization.

If the bottom of the beam does not clear an obstacle by 500 feet and the beam is more than 50% blocked beyond the obstacle, data from the next higher elevation angle is used.

Sectorized Hybrid Scan

The sectorized hybrid scan is a combination of radials using the default hybrid scan and higher elevations defined by beam blockage requirements. See Fig. 8-33.

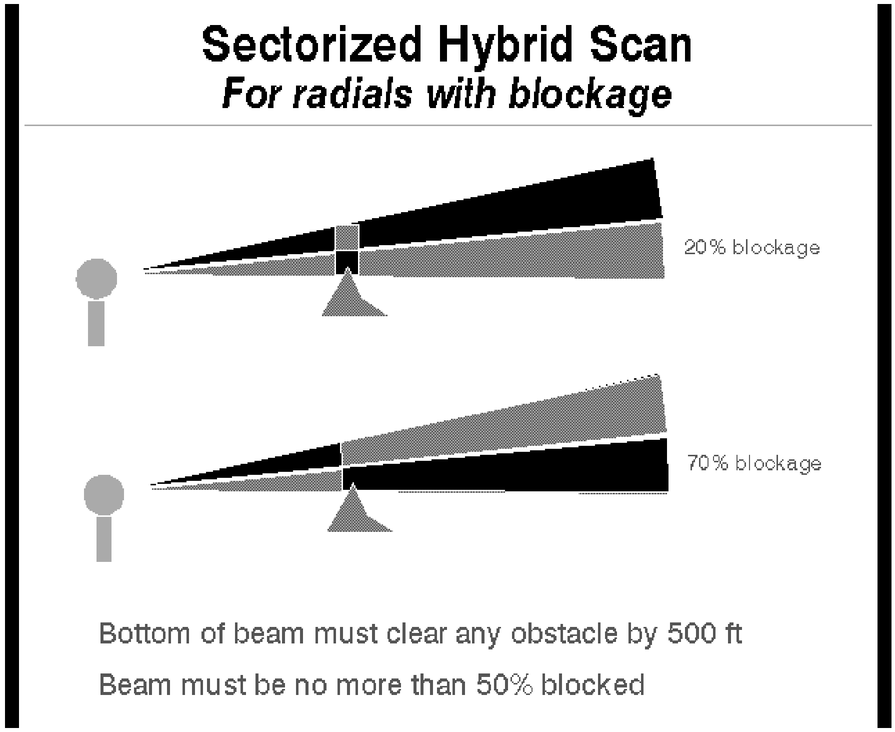


Figure 8-33. Sectorized Hybrid Scan and the beam blockage requirements.

Bi-Scan Maximization

Bi-Scan Maximization is used beyond 27 nm to help reduce the effects of beam losses at far ranges. This technique chooses the greater reflectivity value of the lowest 2 elevation angles, unless the lowest angle was discarded in the tilt test.

Overestimation of precipitation amounts due to bright band or virga can be minimized by properly setting the minimum range (MNRBI) for which Bi-Scan Maximization will be applied. For example, with a bright band event, MNRBI can be selected so that the Bi-Scan Maximization is applied beyond the range where the 1.5^{o} elevation would be selected. See Fig. 8-34.

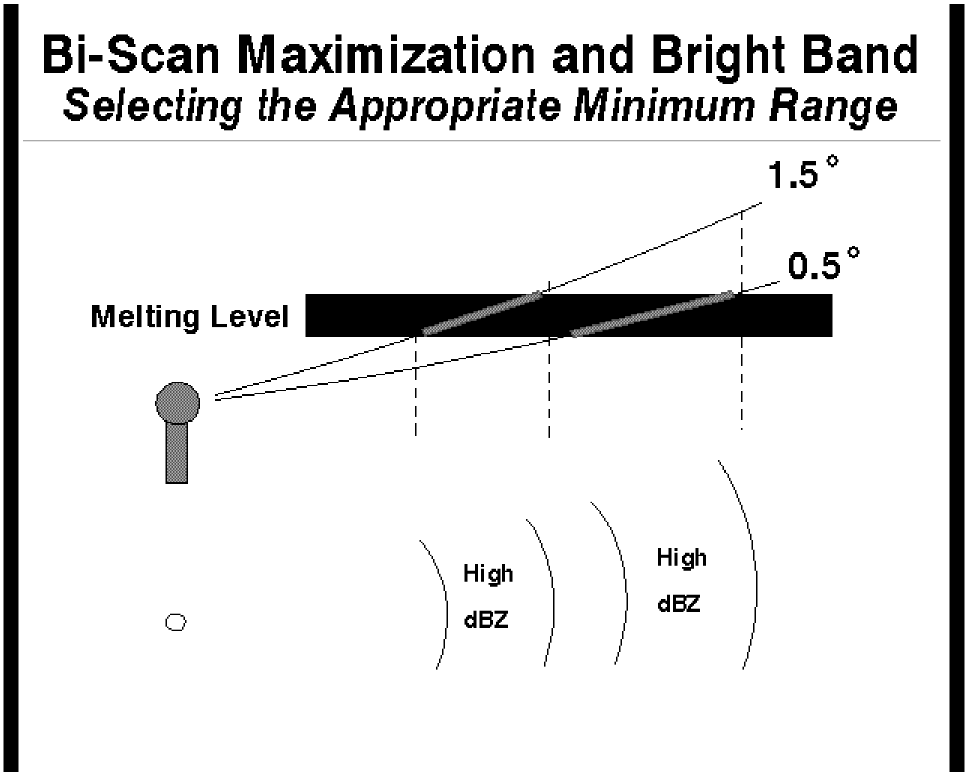


Figure 8-34. Bi-Scan Maximization and the Bright Band

The output from the 5 quality control steps is the 1^0 x .54 nm hybrid scan, which selects the best available estimate of low level reflectivity for conversion to rainfall rate. In addition to the remaining precipitation algorithms, the hybrid scan is the input for the generation of the Radar Coded Message.

Input to Precipitation Processing

Interim Summary

Digitized Base Reflectivity Data from four lowest elevation angles transmitted to RPG for processing

Precipitation Detection Function

Precipitation Category assigned each volume scan

Gage Data Support System - Activated by category 1 or 2

Preprocessing Algorithm

Quality Control Steps

Hybrid Scan Construction

Precipitation Rate Algorithm

See Supplementary Material 8-5-3 for information on the adaptable parameters in the Precipitation Rate Algorithm.

Hybrid Scan

From the hybrid scan, reflectivity data (dBZ) are converted to rainfall rate using Z-R relationship

The input to the Precipitation Rate algorithm is the best possible low level reflectivity value at each .54 nm x 1^o sample volume that was created by the hybrid scan. The reflectivity data (dBZ) is converted to rainfall rates (dBR, decibels of R, dBR=10 log R) using a Z-R relationship. The default relationship is $Z = 300R^{1.4}$, but is adaptable under OSF supervision. For example, a tropical Z/R relationship is available for gulf coast sites. The data resolution is changed, then two quality control steps are applied, the time continuity test and a correction for range effects.

Converts .54 nm x 1^o rate data to 1.1 nm x 1^o

The rainfall rates at the .54 nm x 1^o resolution are converted to a new resolution, 1.1 nm x 1^o. This is done by averaging the rates in two adjacent .54 nm range bins, and placing the average in the corresponding 1.1 nm bin.

Time Continuity Check

The first quality control step is the time continuity test, an evaluation of the time continuity of the total field volumetric precipitation rate. It is a check for an increase or decrease of the total volumetric precipitation rate that exceeds any increase or decrease due to precipitation development or decay. This test can remove an entire volume scan when an increase or decrease from one scan to the next is physically unrealistic. This could occur as a result of:

1) anomalous propagation of the radar beam

2) radio frequency interference

3) system noise

4) lower transmitted power

5) reduction in echo due to the tilt test removing the 0.5° elevation

If the change in total volumetric water accumulation (increase or decrease) between scans exceeds a computed threshold, the scan is considered unreliable and is thrown out. This test will not be conducted when the time between scans exceeds 15 minutes.

Range Correction

The second quality control step is the range correction. This feature, when activated, corrects for underestimation of precipitation rates at long ranges due to signal degradation and partial beam filling. The Bi-scan maximization of the hybrid scan used in the Preprocessing algorithm will improve range performance, but more correction is needed for partial beam filling.

This correction will be done using the following equation.

$R_{corrected} = a\,[(R_{detected})^{b} r^{c}]$

where R = rainfall rate, in mm/hr

r = range, in km

The coefficients a, b, & c will vary from season to season and from site to site. At the present time, no correction is made so a=1 ,b=1, c=0, and $R_{corrected}=R_{detected}$. These coefficients may be adjusted, based on knowledge of radar beam characteristics, local storm climatology, and terrain. Additional research needs to be completed before effective corrections can be applied.

Precipitation Accumulation Algorithm

See Supplementary Material 8-5-4 for information on the adaptable parameters in the Precipitation Accumulation Algorithm

Scan-to-Scan Accumulations

Computed from the current and previous scan

Used to generate the Storm Total Product

The Precipitation Accumulation algorithm takes the output from the Precipitation Rate algorithm (rainfall rates for each 1^{o} X 1.1 nm) and produces scan to scan and hourly accumulations for each 1^{o} X 1.1 nm sample volume. The Precipitation Accumulation algorithm also tests the rainfall accumulations for outliers and checks for missing rate scans.

The volume scan to volume scan accumulations are produced for the Storm Total Precipitation Product. The Storm Total will update each volume scan for the duration of category 1 or 2.

Hourly Accumulations

Computed from the scan-to-scan data

Three types of hourly accumulations:

1. One hour ending at the current volume scan

The first type of hourly accumulation is one hour ending at the current volume scan, and is used to produce the One Hour Product. The One Hour Product is a moving one hour window that is updated:

every 5 or 6 minutes if in mode A

every 10 minutes if in mode B

2. One hour ending at the top of each hour

The second type of hourly accumulation is one hour ending at the top of the hour. Two out of three top of the hour (or clock hour) accumulations are required to produce a Three Hour Product. This Product is available each volume scan, but is updated ONLY at the top of each hour.

Example

Rain starts at 2:43 pm and stops at 4:30 pm.

The first nonzero accumulation would be one hour ending at 3:00 pm. The second accumulation would be one hour ending at 4:00 pm, and the third would be one hour ending at 5:00 pm.

The Three Hour product would be available the first volume scan after 3:00 pm, since two top of the hour accumulations would be available:

1:00 - 2:00, zero accumulation

2:00 - 3:00, nonzero accumulation

3. One hour ending at gage accumulation time

The third type of hourly accumulation is one hour ending at gage accumulation time. This data will be used to compute the radar/gage bias.

Check for Missing Data

The Accumulation algorithm also checks for and attempts to correct for missing rate scans. As the time between scans increases, so also increases the error in the precipitation estimate. For example, an outage time of 10 minutes statistically results in 15% error, while an outage time of 15 minutes results in 25% error. In this setting, an outage is any type of failure that prevents base data from being received at the RPG.

In the Accumulation algorithm, if the time between consecutive scans is less than or equal to 30 minutes, the precipitation accumulations are averaged between the last good volume scan and the first good one. This average is then multiplied by the time between scans (outage time), which has also changed. See Fig. 8-35.

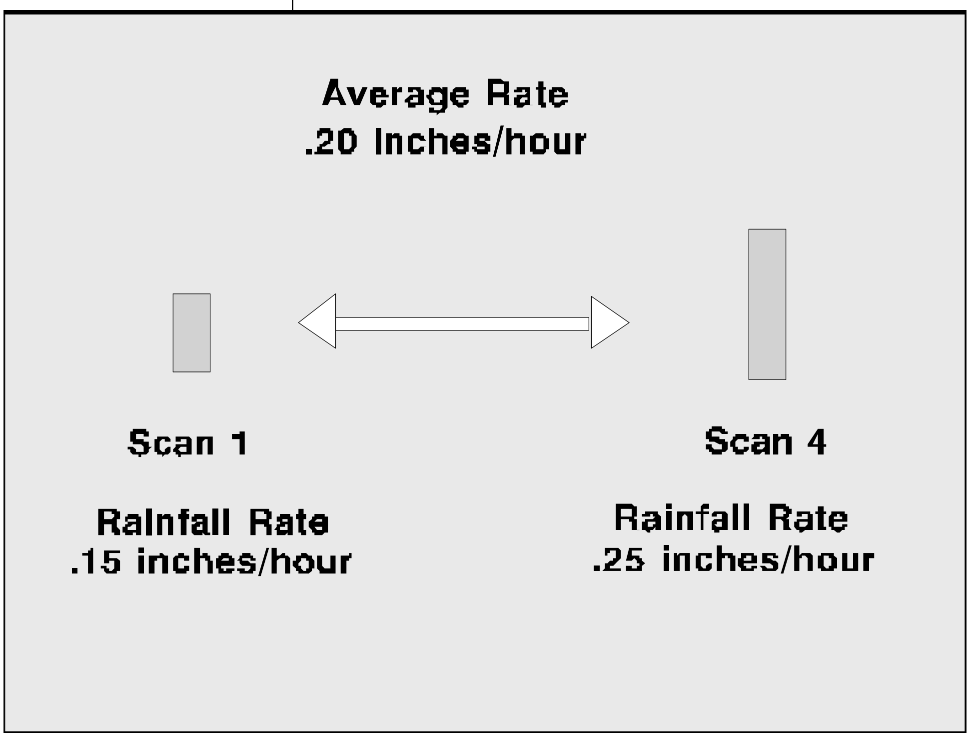


Figure 8-35. Radar outage less than 30 minutes. No data are labeled missing.

If the time between consecutive volume scans is greater than 30 minutes, the Accumulation algorithm continues to use the rate from the last good volume scan for an additional 15 minutes. The final 15 minutes of the outage is assigned the value from the first good volume scan after the outage. The excess time between the two scans is considered missing. See Fig. 8-36.

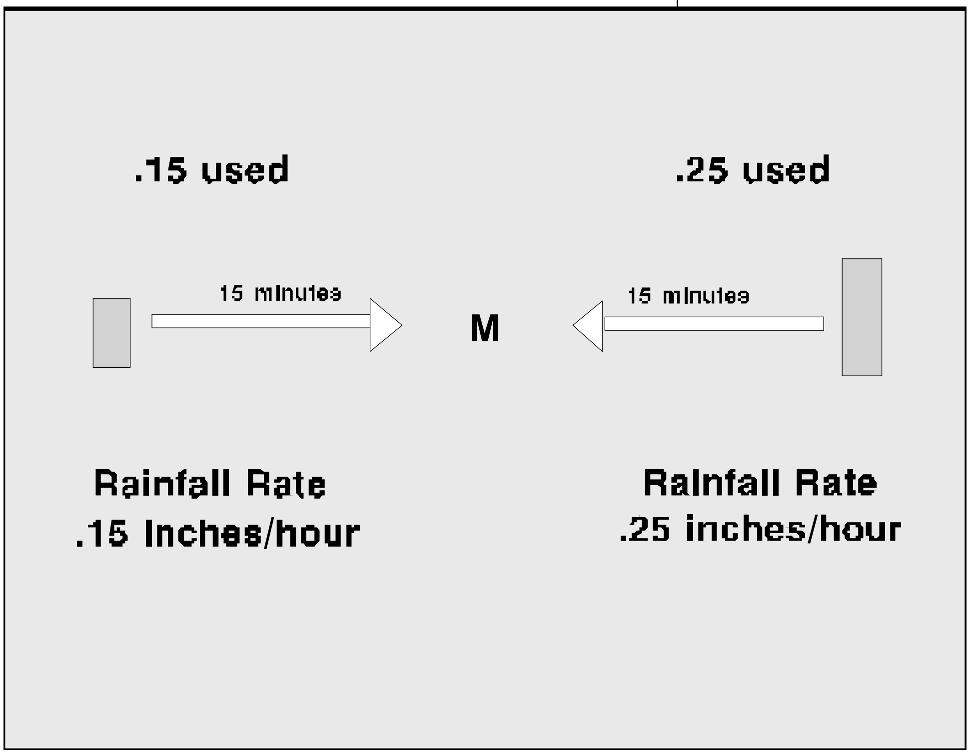


Figure 8-36. Radar outage longer than 30 minutes. Data beyond 30 minutes are labeled missing.

If missing data exceeds 6 minutes (radar outage exceeds 36 minutes), hourly accumulations are not computed.

1. One Hour Product not generated.

2. Three Hour Product not generated until 2 (out of 3) top of the hour accumulations (zero or nonzero) are available. This product may include missing data.

3. Storm Total Product will be generated though data are missing.

In category 0, "zeros" are accumulated; a zero accumulation is ***not*** missing data.

Hourly Accumulation

Checks hourly accumulations for excessively high amounts

The last step in the Accumulation Algorithm is to check for accumulation outliers (unreasonably high accumulations). If an accumulation exceeds a preset threshold, that amount will be reduced to the average of its neighbors. The current default for this adaptable parameter is 15.6 in/hr. However, with the parameter "Max dBZ for converting to precipitation rate" set at 53 dBZ, the maximum accumulation possible is 4.09 in/hr.

Interim Summary

Preprocessing Algorithm

Several quality control steps applied to Base Reflectivity Data

Hybrid Scan constructed

Rate Algorithm

Reflectivity converted to Rainfall Rate at .54 nm x 1^{o} resolution

Resolution changed to 1.1 nm x 1^{o}

Accumulation Algorithm

Scan-to-scan and hourly accumulations computed

Checks for missing periods of data

Precipitation Adjustment Algorithm

See Supplementary Material 8-5-5 for information on the adaptable parameters in the Precipitation Adjustment Algorithms.

Remaining errors that are difficult to correct:

1. Non-representative Z-R relationship

2. Incorrect hardware calibration

Radar estimates adjusted by applying a multiplicative bias

Ability to receive real-time gage data will vary from site to site

Adjustment Bias Computed Using Kalman Filter

Computed bias reflects long term gage/radar differences

Method is conservative; designed to compensate for non-representative Z-R relationship.

Each hour, the previous hour's bias is modified using current gage data and radar estimates. The bias will change only in response to long term gage/radar differences.

Computed bias is a function of the number of gages available that hour (small number of gages result in small change in the bias).

Each hour, computes a multiplicative bias from up to 30 (out of 50) gages.

Bias computation not contaminated by large errors

Gage/radar pairs with small values (less than .024 inches) are eliminated. These small values can result in large errors.

Eliminates gage/radar pairs whose difference is significantly greater than the remaining pairs (more than two standard deviations)

Bias and Error Variance Provided

For each product, the hourly bias and the error variance can be seen at the applications terminal.

If a new bias cannot be computed, then the bias from previous hour is carried over and applied.

If bias is carried over for more that 1 hour, and category 0 is detected, the bias drifts back to its reset values over a set time. The reset values, 1.0 for bias and 0.5 for mean square error, as well as the reset bias time, 12 hours, are all adaptable parameters under OSF control.

The bias is applied over the entire 124 nm range

If the bias is determined to be inaccurate by the operator, then the bias may be toggled off at the UCP. Any subsequent One Hour Precipitation (OHP) and Three Hour Precipitation (THP) products requested will not have the bias applied. Any subsequent Storm Total Precipitation products requested will have partially biased and partially unbiased data, until Category 0 is assigned and the STP resets. The Digital Precipitation Array (DPA) does not have the bias applied to it, and so is not affected by this function.

See Supplementary Material 8-5-9 for additional information on the Precipitation Adjustment Algorithm.

Summary - Algorithm Section

Precipitation Detection Function

Precipitation category determined

Preprocessing Algorithm

Quality control applied; hybrid scan constructed

Rate Algorithm

Reflectivity converted to rainfall rate

Accumulation Algorithm

Scan-to-scan and hourly accumulations computed

Adjustment Algorithm

Hourly accumulations adjusted by Kalman Filter bias

Precipitation Processing Subsystem - Strengths

Only source of real time high resolution rainfall accumulations

Significant quality controls designed to produce better products by

1. minimizing overestimation from ground clutter and anomalous propagation
2. improving range performance
3. eliminating outliers

Built in statistical technique to adjust the radar estimates

Precipitation Processing Subsystem - Limitations

Algorithms do not account for

1. bright band contamination
2. rain gage inaccuracies and sampling errors
3. non-uniform distribution of rainfall

Algorithms do not always account for

1. hail contamination
2. inaccuracies due to radar outages

3. variations in Z-R relationships

4. incorrect hardware calibration
5. inadequate number of gages

Precipitation Products

Precipitation Product Generation

For One Hour, Three Hour, and Storm Total Products:

Accumulations in 1.1 nm x 1^{o} polar form

For One Hour Digital Product:

Accumulations in 1.1 nm x 1^{o} polar form converted to 1/40th LFM (2.2 x 2.2 nm) rectangular grid

One Hour Digital Precipitation Array

1.1 nm x 1^{o} polar grid data converted to 1/40th LFM rectangular grid average of centroids)

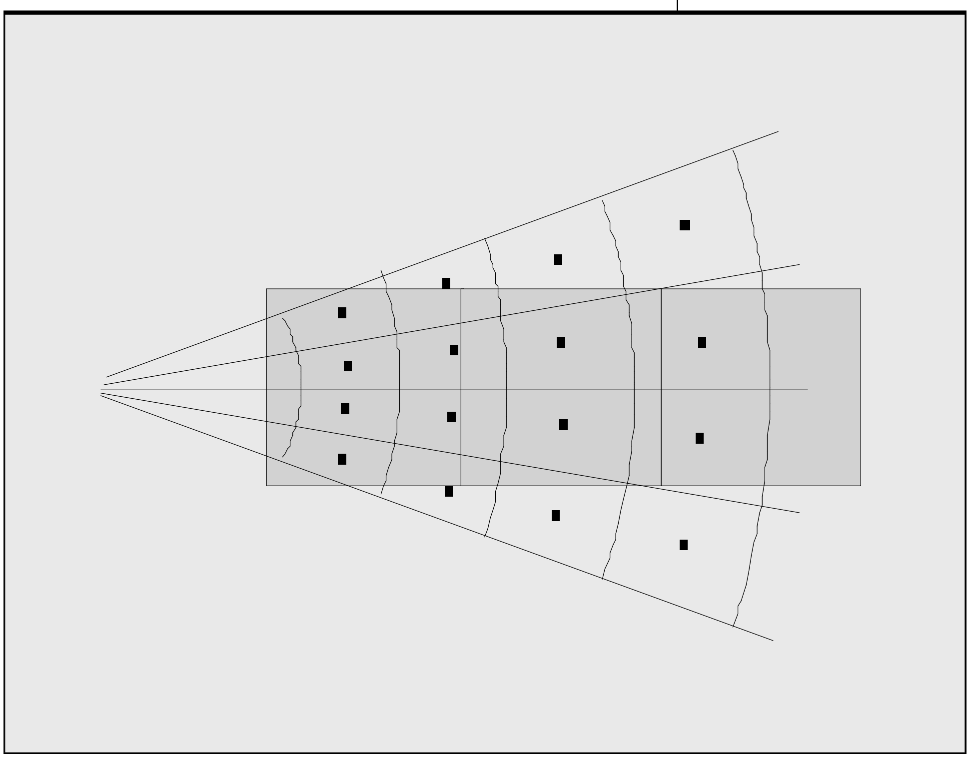


Figure 8-37. Conversion to LFM grid

Precipitation Products

At the PUP

Graphical products

- One Hour Precipitation (OHP) #78

- Three Hour Precipitation (THP) #79
- Storm Total Precipitation (STP) #80
- User Selectable Precipitation (USP) #31

Alphanumeric products

- Supplemental data (OHP, THP, STP)
- Supplemental Precipitation Data (SPD) #82

Not at the PUP; for downstream processing

- Digital products
- One Hour Digital Precipitation Array (DPA) #81

One Hour Precipitation

Product #78 ID OHP (Fig. 8-38)

Displays accumulations for the past hour

Available from the first volume scan with detected rainfall (category 1 or 2)

Updated every volume scan after the first product - a moving one hour window of precipitation

16 data levels available, with a range of 0.00 to 12.70 inches available in multiples of 0.05 inch. Data level values are selected at the UCP, and are under URC change authority.

See Supplementary Material 8-5-9 for precipitation data levels adaptable parameters.

Supplemental information is available at the Applications Terminal.

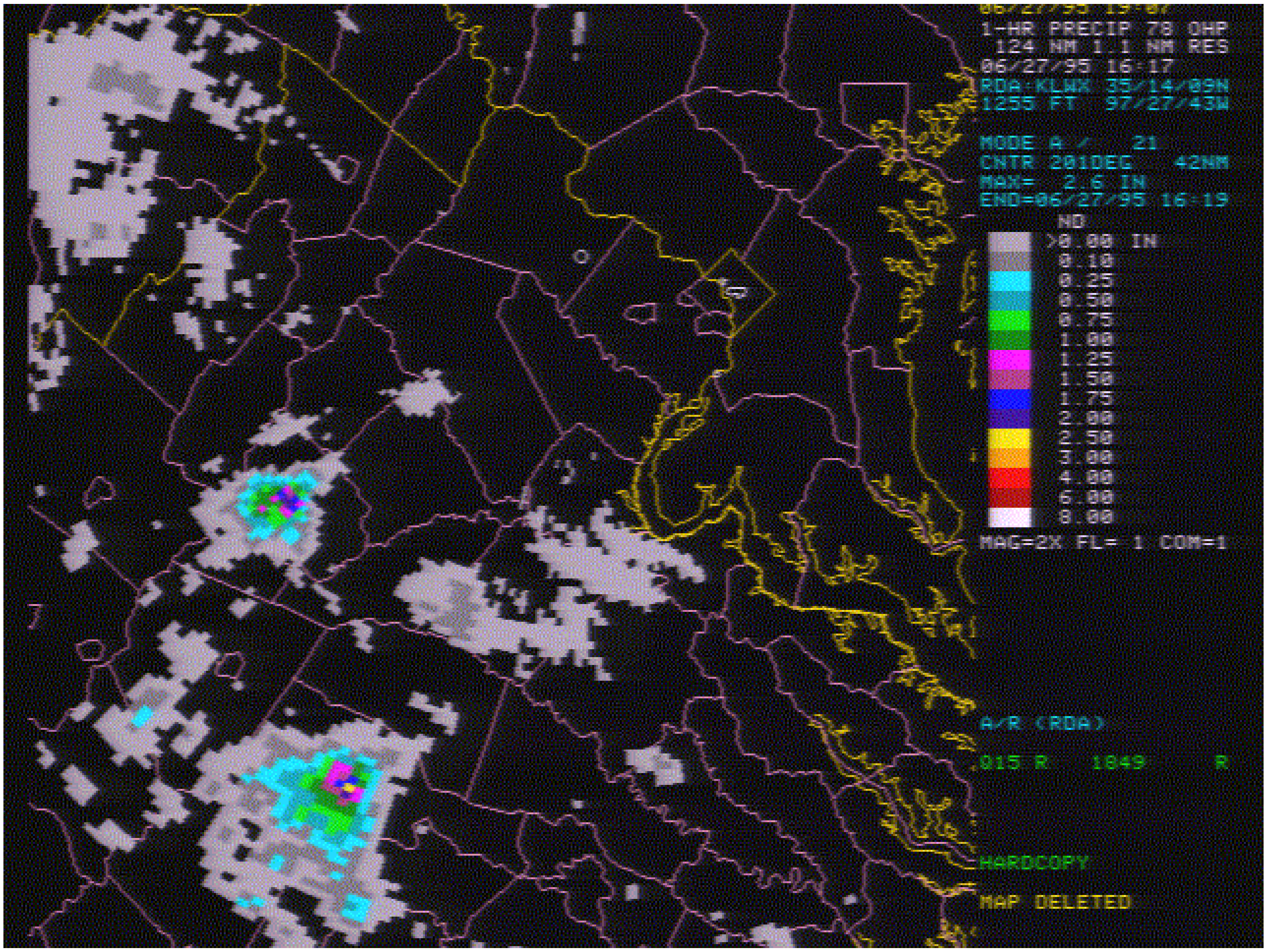
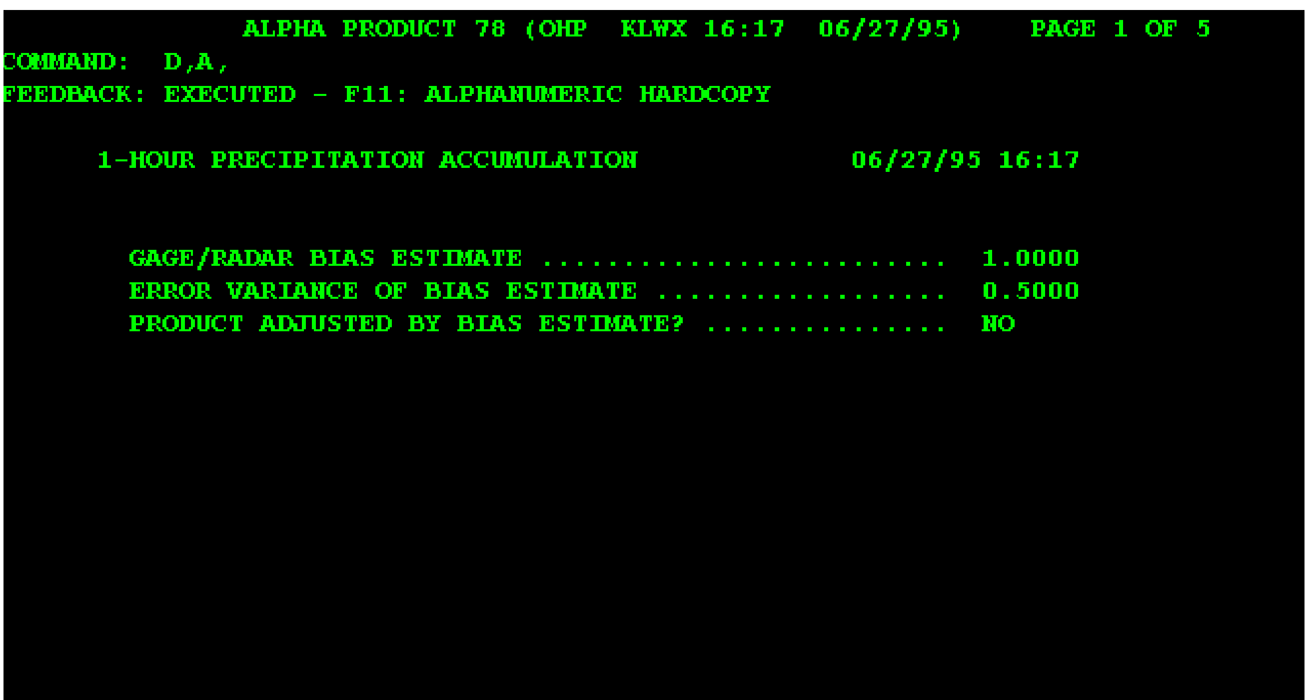


Figure 8-38. One Hour Precipitation


ALPHA PRODUCT 78 (OHP KLWX 16:17 06/27/95) PAGE 1 OF 5
COMMAND: D,A,
FEEDBACK: EXECUTED - F11: ALPHANUMERIC HARDCOPY

1-HOUR PRECIPITATION ACCUMULATION 06/27/95 16:17

GAGE/RADAR BIAS ESTIMATE 1.0000
ERROR VARIANCE OF BIAS ESTIMATE 0.5000
PRODUCT ADJUSTED BY BIAS ESTIMATE? .... NO

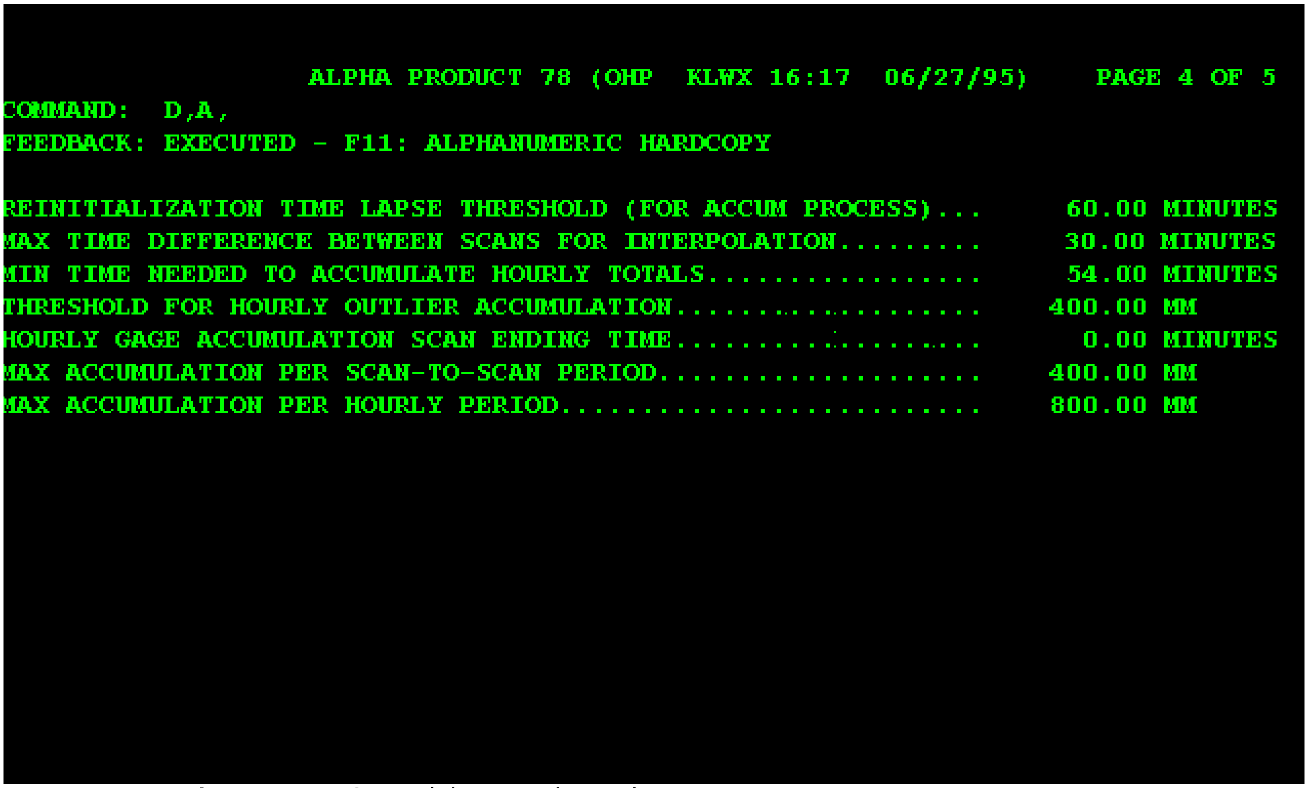
Figure 8-39. OHP Alphanumeric Product, page 1.

```
                     ALPHA PRODUCT 78 (OHP  KLWX 16:17  06/27/95)     PAGE 2 OF 5
COMMAND:  D,A,
FEEDBACK: EXECUTED - F11: ALPHANUMERIC HARDCOPY

MIN THRESHOLD DBZ FOR ISOLATED BIN TEST.....................       18.00 DBZ
MAX DBZ ALLOWED BEFORE BEING LABELED AS OUTLIER.............       65.00 DBZ
TILT-TEST LOW REFLECTIVITY (DBZ) VALUE......................        1.00 DBZ
INNER RANGE LIMIT FOR TILT TEST.............................       40.00 KM
OUTER RANGE LIMIT FOR TILT TEST.............................      150.00 KM
MAX RANGE OF BI-SCAN MAXIMIZATION...........................      230.00 KM
MIN PRECIP ECHO AREA NEEDED FOR TILT TEST IN LOW ELEV.......      600.00 KM**2
MIN AREA-WGTD-REFLECT. NEEDED FOR TILT TEST IN LOW ELEV.....       10.00 DBZ
MAX % AREA REDUCTION BETWEEN 2 LOWEST ELEVATIONS............       75.00  %
REFLECT-TO-PRECIP RATE CONVERSION MULTIPLICATIVE COEFFICIENT      300.00
REFLECT-TO-PRECIP RATE CONVERSION POWER COEFFICIENT.........        1.40
MIN DBZ FOR CONVERTING TO PRECIP RATE (VIA TABLE LOOKUP)....        0.00 DBZ
MAX DBZ FOR CONVERTING TO PRECIP RATE (VIA TABLE LOOKUP)....       65.00 DBZ
MIN RANGE OF BI-SCAN MAXIMIZATION...........................      180.00 KM
```

Figure 8-40. OHP Alphanumeric Product, page 2.

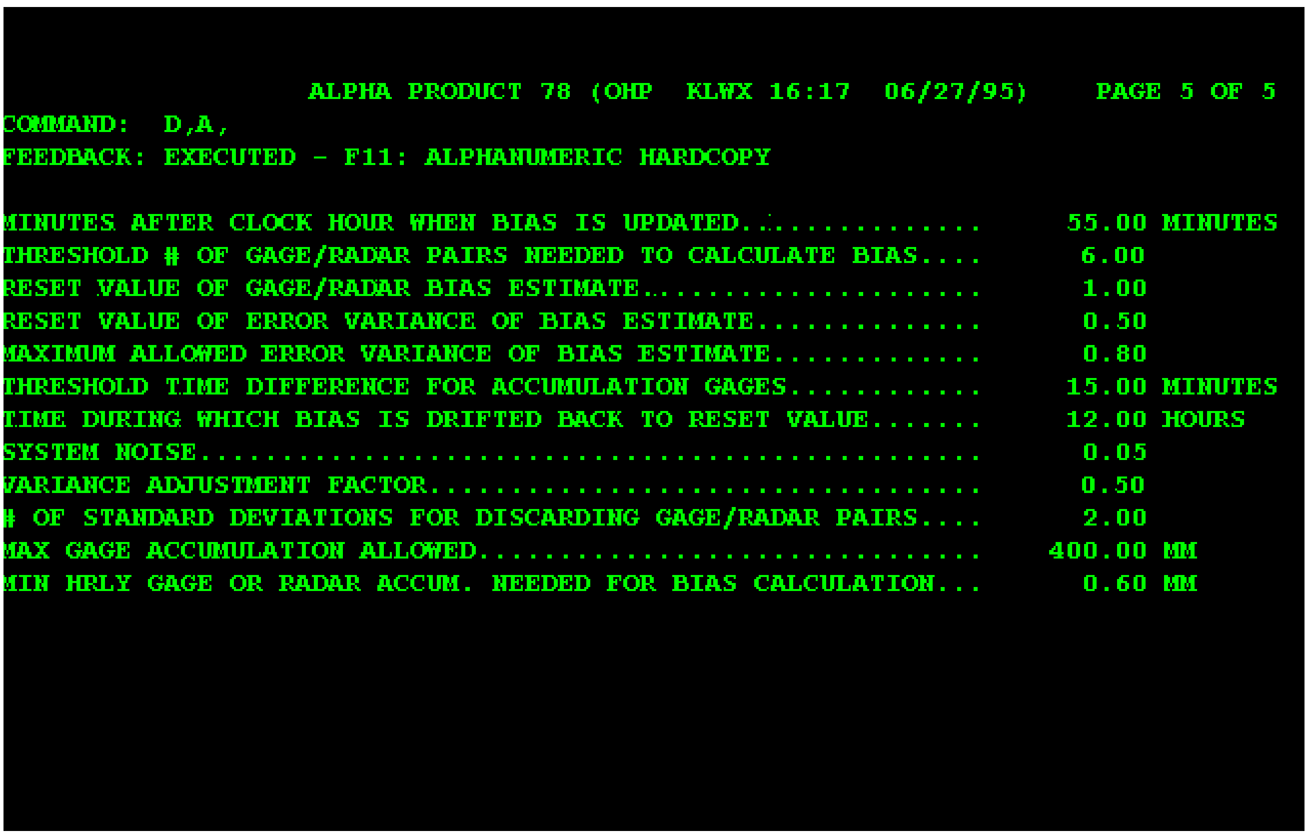
```
                     ALPHA PRODUCT 78 (OHP  KLWX 16:17  06/27/95)    PAGE 3 OF 5
COMMAND:  D,A,
FEEDBACK: EXECUTED - F11: ALPHANUMERIC HARDCOPY

MAX STORM SPEED (M/SEC).....................................     25.00 M/SEC
MAX SCAN-TO-SCAN TIME DIFFERENCE FOR TIME CONTINUITY TESTS..     15.00 MINUTES
MIN PRECIP-AREA FOR PERFORMING TIME CONTINUITY TESTS........    240.00 KM**2
RATE OF CHANGE: VOLUMETRIC PRECIP RATE, MIN ECHO AREA.......     24.00 1/HR
RATE OF CHANGE: VOLUMETRIC PRECIP RATE, FULL ECHO UMBRELLA..     13.00 1/HR
MAX ECHO-AREA RATE OF CHANGE................................    200.00 KM**2/HR
RANGE BEYOND WHICH TO APPLY RANGE-EFFECT CORRECTION.........    230.00 KM
1ST COEFFICIENT OF RANGE-EFFECT FUNCTION....................      0.00 DBR
2ND COEFFICIENT OF RNAGE-EFFECT FUNCTION....................      1.00
3RD COEFFICIENT OF RANGE-EFFECT FUNCTION....................      0.00
MIN RATE SIGNIFYING PRECIPITATION...........................      0.00 MM/HR
MAX PRECIPITATION RATE......................................    103.80 MM/HR
```

Figure 8-41. OHP Alphanumeric Product, page 3.



```
                  ALPHA PRODUCT 78 (OHP  KLWX 16:17  06/27/95)    PAGE 4 OF 5
COMMAND:  D,A,
FEEDBACK: EXECUTED - F11: ALPHANUMERIC HARDCOPY

REINITIALIZATION TIME LAPSE THRESHOLD (FOR ACCUM PROCESS)...     60.00 MINUTES
MAX TIME DIFFERENCE BETWEEN SCANS FOR INTERPOLATION.........     30.00 MINUTES
MIN TIME NEEDED TO ACCUMULATE HOURLY TOTALS.................     54.00 MINUTES
THRESHOLD FOR HOURLY OUTLIER ACCUMULATION...................    400.00 MM
HOURLY GAGE ACCUMULATION SCAN ENDING TIME...................      0.00 MINUTES
MAX ACCUMULATION PER SCAN-TO-SCAN PERIOD....................    400.00 MM
MAX ACCUMULATION PER HOURLY PERIOD..........................    800.00 MM
```

Figure 8-42. OHP Alphanumeric Product, page 4.



```
                  ALPHA PRODUCT 78 (OHP  KLWX 16:17  06/27/95)    PAGE 5 OF 5
COMMAND:  D,A,
FEEDBACK: EXECUTED - F11: ALPHANUMERIC HARDCOPY

MINUTES AFTER CLOCK HOUR WHEN BIAS IS UPDATED...............     55.00 MINUTES
THRESHOLD # OF GAGE/RADAR PAIRS NEEDED TO CALCULATE BIAS....      6.00
RESET VALUE OF GAGE/RADAR BIAS ESTIMATE.....................      1.00
RESET VALUE OF ERROR VARIANCE OF BIAS ESTIMATE..............      0.50
MAXIMUM ALLOWED ERROR VARIANCE OF BIAS ESTIMATE.............      0.80
THRESHOLD TIME DIFFERENCE FOR ACCUMULATION GAGES............     15.00 MINUTES
TIME DURING WHICH BIAS IS DRIFTED BACK TO RESET VALUE.......     12.00 HOURS
SYSTEM NOISE................................................      0.05
VARIANCE ADJUSTMENT FACTOR..................................      0.50
# OF STANDARD DEVIATIONS FOR DISCARDING GAGE/RADAR PAIRS....      2.00
MAX GAGE ACCUMULATION ALLOWED...............................    400.00 MM
MIN HRLY GAGE OR RADAR ACCUM. NEEDED FOR BIAS CALCULATION...      0.60 MM
```

Figure 8-43. OHP Alphanumeric Product, page 5.

One Hour Precipitation - Applications

Assess rainfall intensities for

1. flash flood warnings or statements, especially in mountainous areas
2. urban flood statements
3. special weather statements
4. conditions affecting airfield drainage

Aid in forecast procedures for flash flood watches, river forecasts, and flood warnings

For fast moving storms, provides storm movement when used in time lapse

Other water management applications

One Hour Precipitation - Limitations

After extended outages, first product will not be generated for 54 minutes

For some events, viewing interval too short

Three Hour Precipitation

Product #79 ID THP (Fig. 8-44)

Product updated once per hour, at the top of the hour

16 data levels available, with a range of 0.00 to 12.70 inches available in multiples of 0.05 inch. Data level values are selected at the UCP, and are under URC change authority. See Supplementary Material 8-5-10 for precipitation data levels adaptable parameters.

Requires two out of past three top of the hour accumulations (zero or nonzero) for product generation

Accumulations updated once per hour

Not recommended for RPS list

Supplemental information available at the Applications Terminal

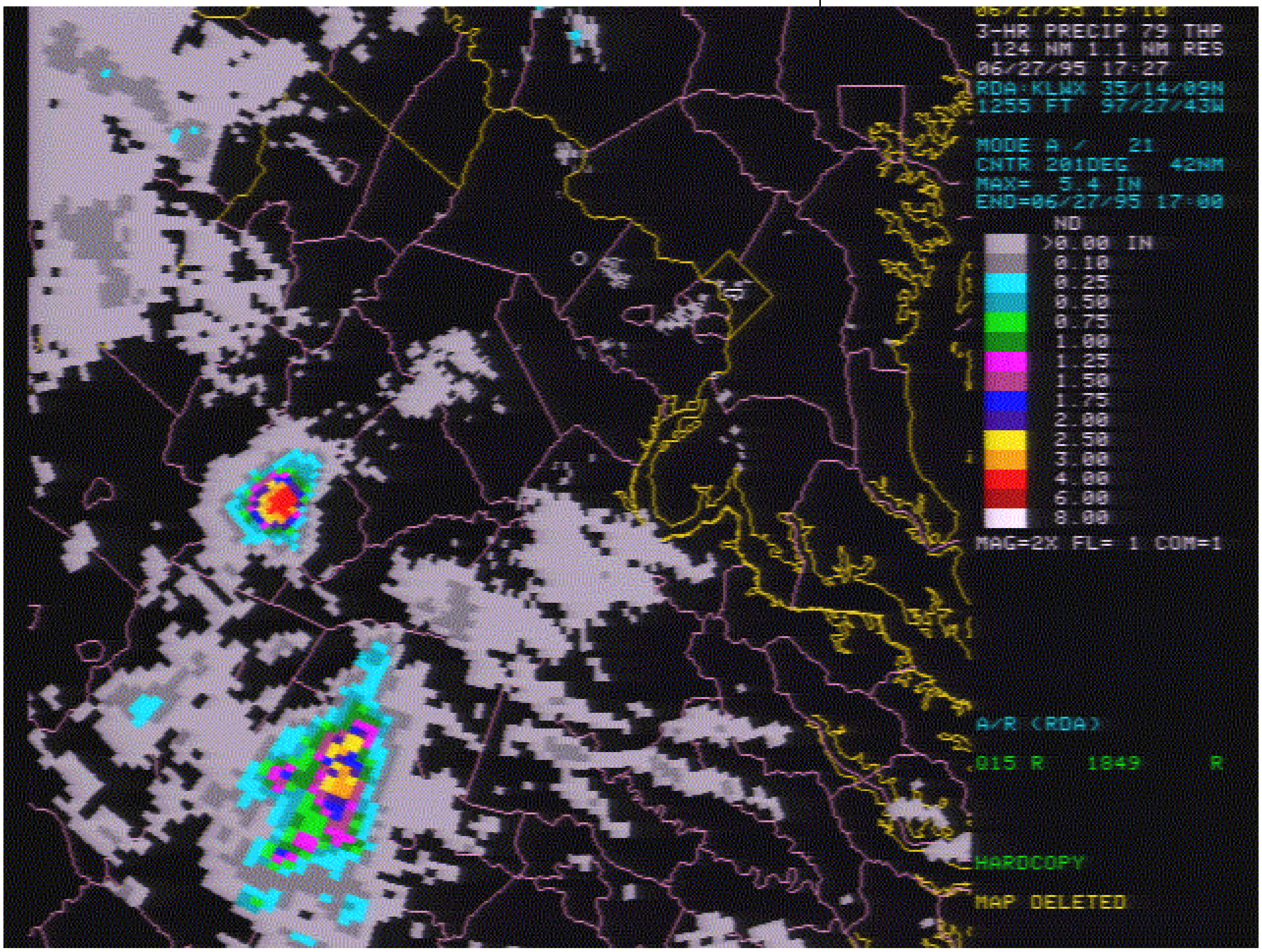


Figure 8-44. Three Hour Precipitation

ALPHA PRODUCT 79 (THP KLWX 17:27 06/27/95) PAGE 1 OF 1

COMMAND: D,A,

FEEDBACK: EXECUTED - F11: ALPHANUMERIC HARDCOPY

3-HOUR PRECIPITATION ACCUMULATION 06/27/95 17:27

NUMBER OF CONTRIBUTING HOURS : 3

(SCAN TYPE: 1=ENDS AT CLOCK HR. 2=ENDS AT GAGE TIME 3=BOTH)

DATE	ENDING	ADJUSTED	BIAS	BIAS-	SCAN
......	HOUR	(Y/N)	....	ERROR-VARIANCE	TYPE
06/27/95	15:00	N	1.00	0.50	3
06/27/95	16:00	N	1.00	0.50	3
06/27/95	17:00	N	1.00	0.50	3

Figure 8-45. THP Alphanumeric Product

Three Hour Precipitation - Applications

1. Provides a longer viewing interval
2. For very long duration events, can be used with Storm Total Product for analysis
3. Corresponds to timing of flash flood guidance values

Three Hour Precipitation - Limitations

1. Product updated only once per hour

Storm Total Precipitation

Product #80 ID STP (Fig. 8-46)

Displays total rainfall accumulation

Available from the first volume scan with detected rainfall (category 1 or 2)

Updated every volume scan as long as the system remains in category 1 or 2

Accumulations reset to zero after one hour of no precipitation (category 0)

16 data levels available, with a range of 0.0 to 25.4 inches available in multiples of 0.1 inch. Data level values are selected at the UCP, and are under URC change authority. See Supplementary Material 8-5-10 for precipitation data levels adaptable parameters.

Highly recommended for RPS list

Supplemental information available at the Applications Terminal

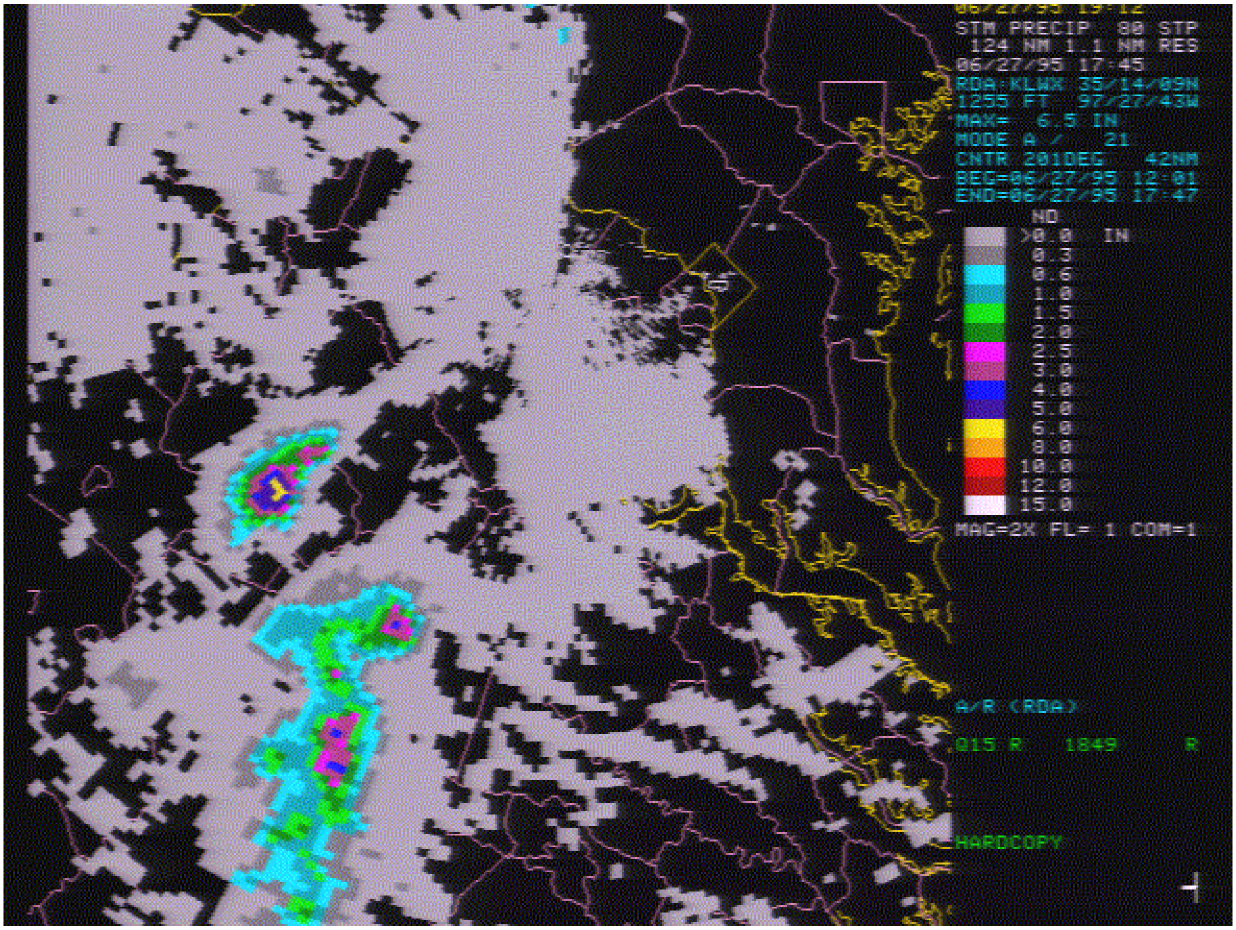


Figure 8-46. Storm Total Precipitation

```
            ALPHA PRODUCT 80 (STP  KLWX 16:17  06/27/95)    PAGE 1 OF 5
COMMAND:  D,A,
FEEDBACK: EXECUTED - F11: ALPHANUMERIC HARDCOPY

     STORM TOTAL PRECIPITATION ACCUMULATION           06/27/95 16:17


       GAGE/RADAR BIAS ESTIMATE ..........................  1.0000
       ERROR VARIANCE OF BIAS ESTIMATE ...................  0.5000
       PRODUCT ADJUSTED BY BIAS ESTIMATE? ................  NO
```

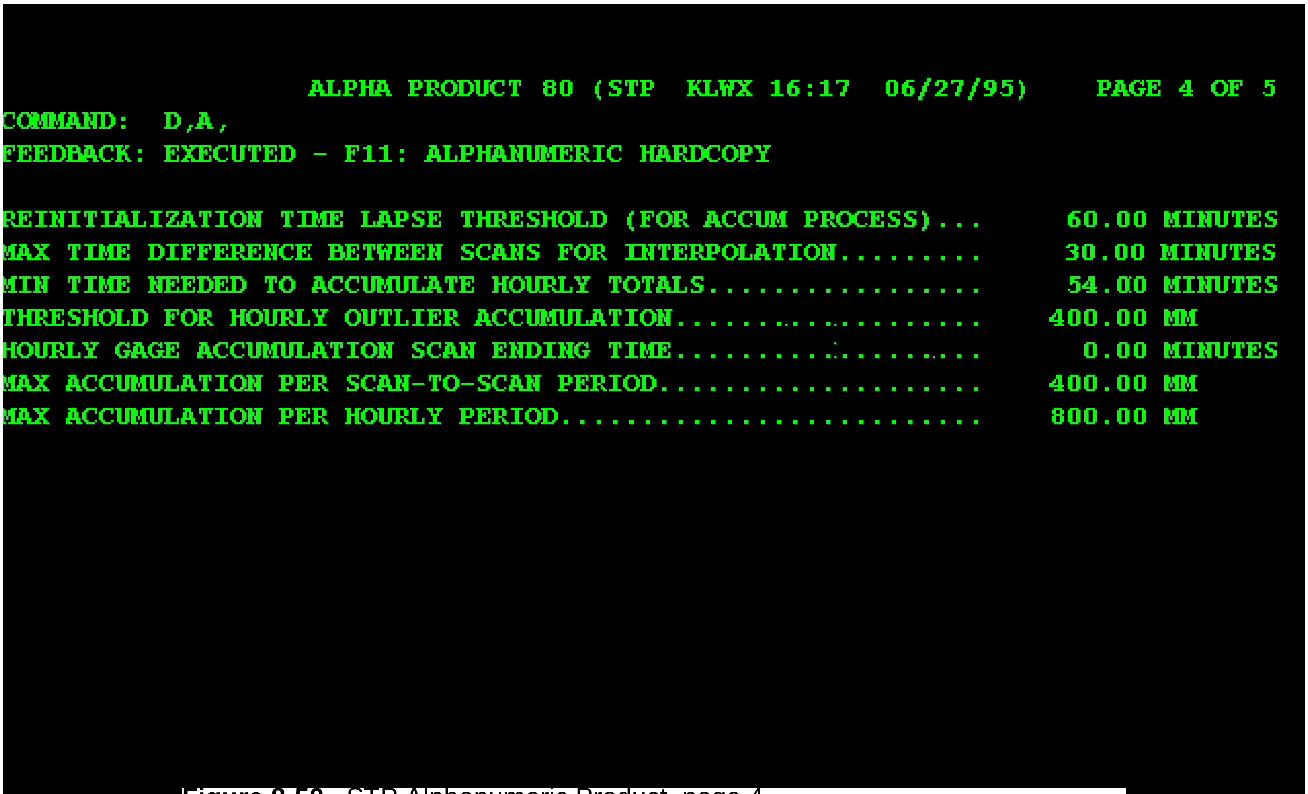
Figure 8-47. STP Alphanumeric Product, page 1.

```
                     ALPHA PRODUCT 80 (STP  KLWX 16:17  06/27/95)     PAGE 2 OF 5
COMMAND:  D,A,
FEEDBACK: EXECUTED - F11: ALPHANUMERIC HARDCOPY

MIN THRESHOLD DBZ FOR ISOLATED BIN TEST.....................       18.00 DBZ
MAX DBZ ALLOWED BEFORE BEING LABELED AS OUTLIER.............       65.00 DBZ
TILT-TEST LOW REFLECTIVITY (DBZ) VALUE......................        1.00 DBZ
INNER RANGE LIMIT FOR TILT TEST.............................       40.00 KM
OUTER RANGE LIMIT FOR TILT TEST.............................      150.00 KM
MAX RANGE OF BI-SCAN MAXIMIZATION...........................      230.00 KM
MIN PRECIP ECHO AREA NEEDED FOR TILT TEST IN LOW ELEV.......      600.00 KM**2
MIN AREA-WGTD-REFLECT. NEEDED FOR TILT TEST IN LOW ELEV.....       10.00 DBZ
MAX % AREA REDUCTION BETWEEN 2 LOWEST ELEVATIONS............       75.00  %
REFLECT-TO-PRECIP RATE CONVERSION MULTIPLICATIVE COEFFICIENT      300.00
REFLECT-TO-PRECIP RATE CONVERSION POWER COEFFICIENT.........        1.40
MIN DBZ FOR CONVERTING TO PRECIP RATE (VIA TABLE LOOKUP)....        0.00 DBZ
MAX DBZ FOR CONVERTING TO PRECIP RATE (VIA TABLE LOOKUP)....       65.00 DBZ
MIN RANGE OF BI-SCAN MAXIMIZATION...........................      180.00 KM
```

Figure 8-48. STP Alphanumeric Product, page 2.

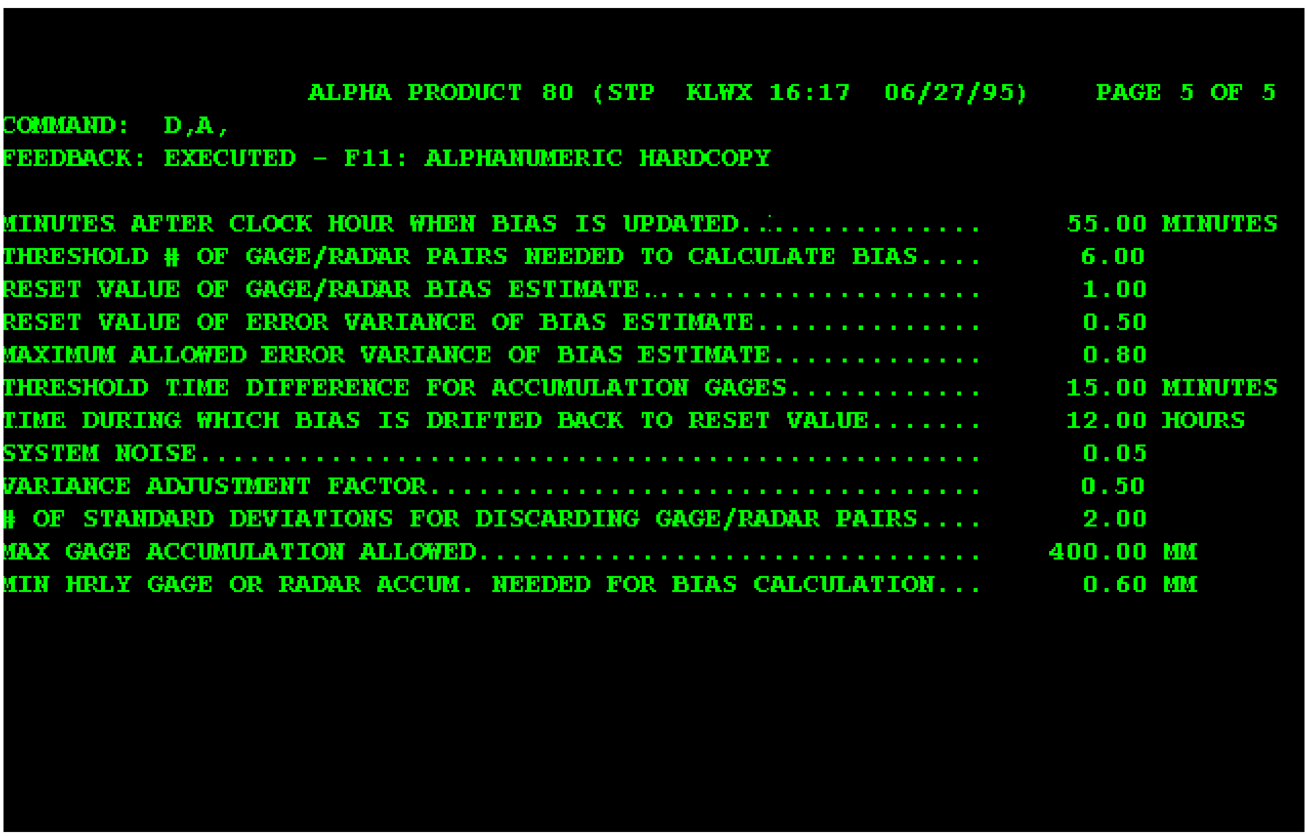
```
                     ALPHA PRODUCT 80 (STP  KLWX 16:17  06/27/95)    PAGE 3 OF 5
COMMAND:  D,A,
FEEDBACK: EXECUTED - F11: ALPHANUMERIC HARDCOPY

MAX STORM SPEED (M/SEC).....................................     25.00 M/SEC
MAX SCAN-TO-SCAN TIME DIFFERENCE FOR TIME CONTINUITY TESTS..     15.00 MINUTES
MIN PRECIP-AREA FOR PERFORMING TIME CONTINUITY TESTS........    240.00 KM**2
RATE OF CHANGE: VOLUMETRIC PRECIP RATE, MIN ECHO AREA.......     24.00 1/HR
RATE OF CHANGE: VOLUMETRIC PRECIP RATE, FULL ECHO UMBRELLA..     13.00 1/HR
MAX ECHO-AREA RATE OF CHANGE................................    200.00 KM**2/HR
RANGE BEYOND WHICH TO APPLY RANGE-EFFECT CORRECTION.........    230.00 KM
1ST COEFFICIENT OF RANGE-EFFECT FUNCTION....................      0.00 DBR
2ND COEFFICIENT OF RNAGE-EFFECT FUNCTION....................      1.00
3RD COEFFICIENT OF RANGE-EFFECT FUNCTION....................      0.00
MIN RATE SIGNIFYING PRECIPITATION...........................      0.00 MM/HR
MAX PRECIPITATION RATE......................................    103.80 MM/HR
```

Figure 8-49. STP Alphanumeric Product, page 3.



```
                    ALPHA PRODUCT 80 (STP  KLWX 16:17  06/27/95)    PAGE 4 OF 5
COMMAND:  D,A,
FEEDBACK: EXECUTED - F11: ALPHANUMERIC HARDCOPY

REINITIALIZATION TIME LAPSE THRESHOLD (FOR ACCUM PROCESS)...     60.00 MINUTES
MAX TIME DIFFERENCE BETWEEN SCANS FOR INTERPOLATION.........     30.00 MINUTES
MIN TIME NEEDED TO ACCUMULATE HOURLY TOTALS.................     54.00 MINUTES
THRESHOLD FOR HOURLY OUTLIER ACCUMULATION...................    400.00 MM
HOURLY GAGE ACCUMULATION SCAN ENDING TIME...................      0.00 MINUTES
MAX ACCUMULATION PER SCAN-TO-SCAN PERIOD....................    400.00 MM
MAX ACCUMULATION PER HOURLY PERIOD..........................    800.00 MM
```

Figure 8-50. STP Alphanumeric Product, page 4.



```
                    ALPHA PRODUCT 80 (STP  KLWX 16:17  06/27/95)    PAGE 5 OF 5
COMMAND:  D,A,
FEEDBACK: EXECUTED - F11: ALPHANUMERIC HARDCOPY

MINUTES AFTER CLOCK HOUR WHEN BIAS IS UPDATED...............     55.00 MINUTES
THRESHOLD # OF GAGE/RADAR PAIRS NEEDED TO CALCULATE BIAS....      6.00
RESET VALUE OF GAGE/RADAR BIAS ESTIMATE.....................      1.00
RESET VALUE OF ERROR VARIANCE OF BIAS ESTIMATE..............      0.50
MAXIMUM ALLOWED ERROR VARIANCE OF BIAS ESTIMATE.............      0.80
THRESHOLD TIME DIFFERENCE FOR ACCUMULATION GAGES............     15.00 MINUTES
TIME DURING WHICH BIAS IS DRIFTED BACK TO RESET VALUE.......     12.00 HOURS
SYSTEM NOISE................................................      0.05
VARIANCE ADJUSTMENT FACTOR..................................      0.50
# OF STANDARD DEVIATIONS FOR DISCARDING GAGE/RADAR PAIRS....      2.00
MAX GAGE ACCUMULATION ALLOWED...............................    400.00 MM
MIN HRLY GAGE OR RADAR ACCUM. NEEDED FOR BIAS CALCULATION...      0.60 MM
```

Figure 8-51. STP Alphanumeric Product, page 5.

Storm Total Precipitation - Applications

1. Monitor total precipitation accumulation
2. Estimate ground saturation and/or total basin runoff
3. Post storm analysis
4. Time lapse for tracking motion of storms

Storm Total Precipitation - Limitations

1. At some sites, system can stay in category 1 or 2 for extended periods of time
2. Product could include missing data without the knowledge of the PUP operator

User Selectable Precipitation

Product #31 ID USP (Fig. 8-52)

Displays precipitation accumulations for a user specified period of time using top of the hour accumulations

User selects duration (up to 24 hours) and end time (up to 6 hours prior to current clock hour)

Default USP generated for 24 hours ending at 12Z

16 data levels available, OHP/THP data levels or STP data levels used dependent on the magnitude of accumulations.

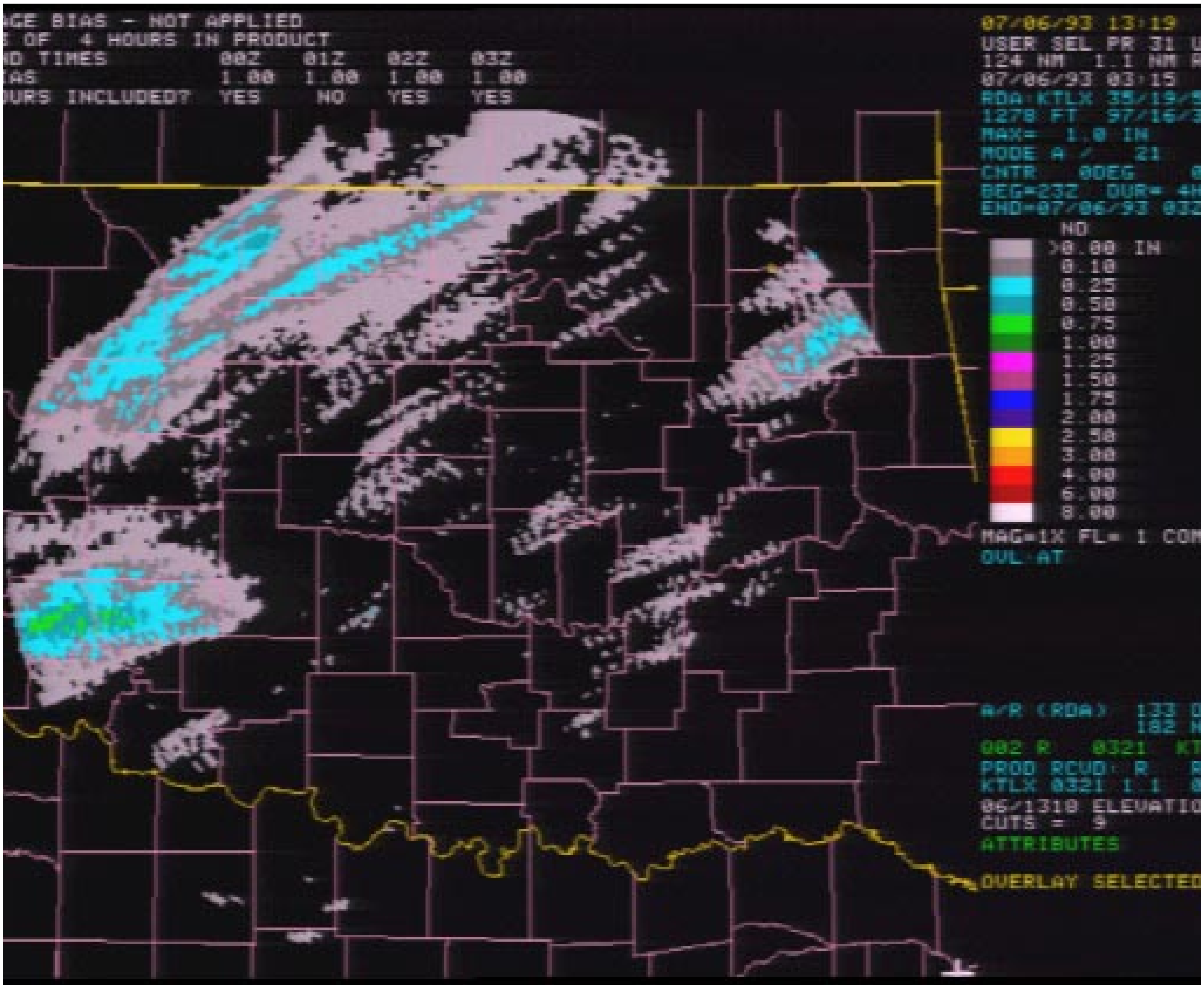


Figure 8-52. User Selectable Precipitation

User Selectable Precipitation - Applications

1. Flexible time interval to meet varying weather situations
2. In addition to the 24 hour default USP, any others generated for APUP is available by OTR to NAPUPs

User Selectable Precipitation - Limitations

1. USP accumulations are updated only at the top of the hour
2. At least two thirds of the specified hourly accumulations must be available for product generation

3. Since the USP is a customized product, only 10 can be generated per volume scan.

One Hour Digital Precipitation Array

Product #81 ID DPA

Available only in hourly form; updated each volume scan

Input into Stage II and Stage III precipitation processing. Stage II and Stage III are additional quality controls applied outside the RPG.

Transmitted automatically to WFOs and RFCs

1/40th LFM (2.2 x 2.2 nm) grid size

256 data levels

One Hour Digital Precipitation Array Applications

1. High data resolution: 256 data levels. Data range is 0.01” to 14.38” in 0.04” increments
2. After downstream quality control (Stage II & Stage III) direct input into NWSRFS (NWS River Forecast System)
3. Grid format allows for mosaicking data from multiple sites for RFC use as well as WFO and (future) national precipitation map
4. Displayable at workstations external to WSR-88D

One Hour Digital Precipitation Array Limitations

1. Not displayable at the PUP
2. Lower spatial resolution

Supplemental Precipitation Data

Product #82 ID SPD

The Supplemental Precipitation Data is an alphanumeric only product received at the PUP like any other product.

Output on PPS algorithms:

1. information on gage-radar pairs
2. number of isolated bins and outliers that are corrected
3. percent echo reduction from 0.5° to 1.5° from the tilt test
4. ratio of range bins chosen from the 1.5° vs 0.5° slices from bi-scan maximization
5. periods of missing data

```
                   ALPHA PRODUCT 82 (SPD  KLWX 19:36  06/27/95)    PAGE 1 OF 2
COMMAND:  D,A,
FEEDBACK: EXECUTED - F11: ALPHANUMERIC HARDCOPY

SUPPLEMENTAL PRECIPITATION DATA - RDA ID     3  06/27/95 19:36

VOLUME COVERAGE PATTERN = 21    MODE = A     TIME CONT: PASSED

       GAGE BIAS APPLIED                   -      NO
            BIAS ESTIMATE                  -     1.00
            VARIANCE                       -   0.5000

       NUMBER OF ISOLATED BINS             -      212
                 INTERPOLATED OUTLIERS     -        0
                 REPLACED OUTLIERS         -        0
                 HOURLY OUTLIERS           -        0

        AREA REDUCTION (PERCENT)           -    24.32
        BI-SCAN RATIO (RATIO)              -     0.43

        MISSING PERIOD: 06/27/95 19:12 06/27/95 19:23
```

Figure 8-53. Supplemental Precipitation Data

Summary - Products Section

Graphical and/or Alphanumeric Products at the PUP

1. One Hour Precipitation
2. Three Hour Precipitation
3. Storm Total Precipitation
4. User Selectable Precipitaiton
5. Supplemental Precipitation Data

Not displayable at the PUP

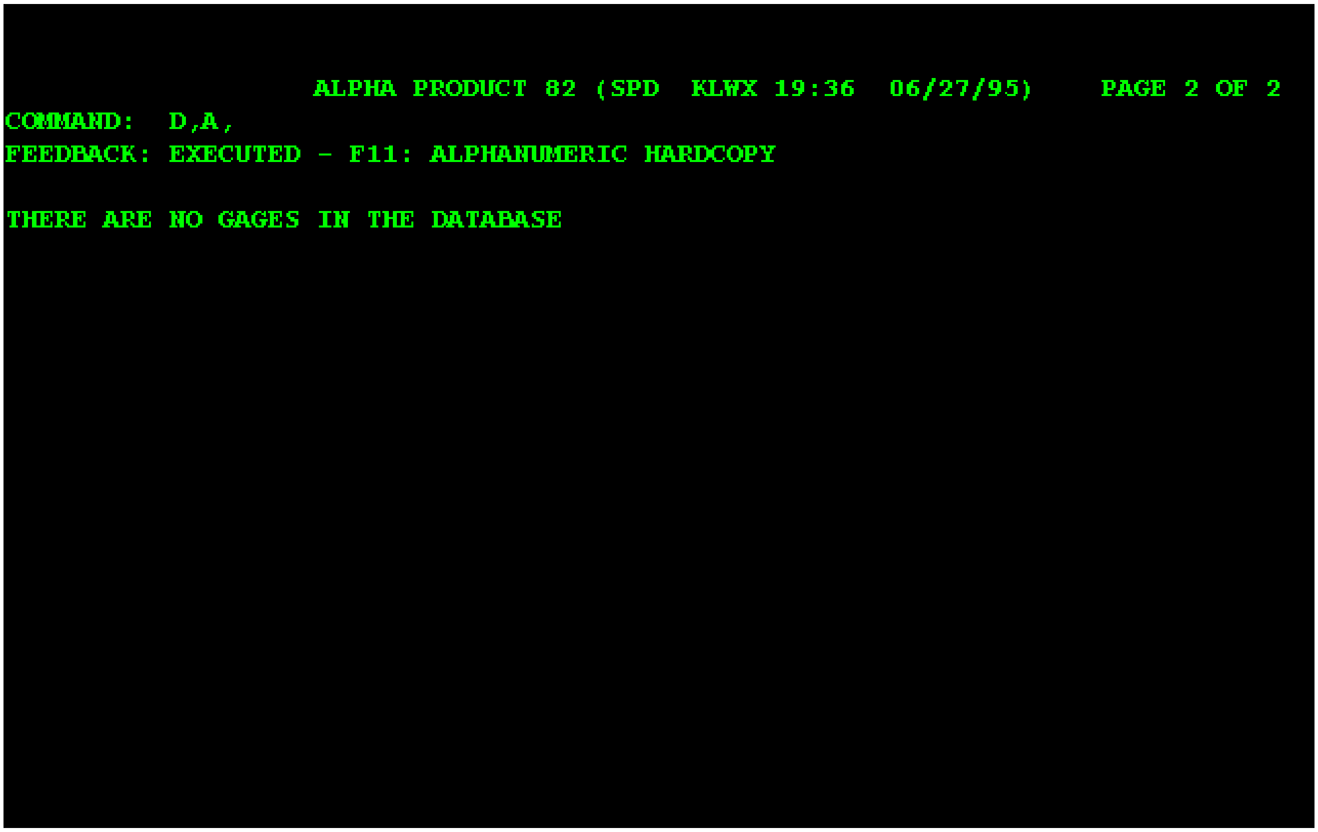


Figure 8-54. Supplemental Precipitation Data

1. One Hour Digital Array

NWS Operations

The precipitation estimation capabilities of the WSR-88D network will significantly change the daily operations of both the Meteorology and Hydrology program within the NWS.

Stage II and Stage III Precipitation Processing

The DPA product from each WSR-88D is Stage I data, with the algorithms described in this course known as Stage I processing.

The objective is to use WSR-88D rainfall estimates to provide a comprehensive database as input to RFC models.

Stage II

Though currently being run at some RFCs, Stage II is envisioned to be run at WFOs as an AWIPS function.

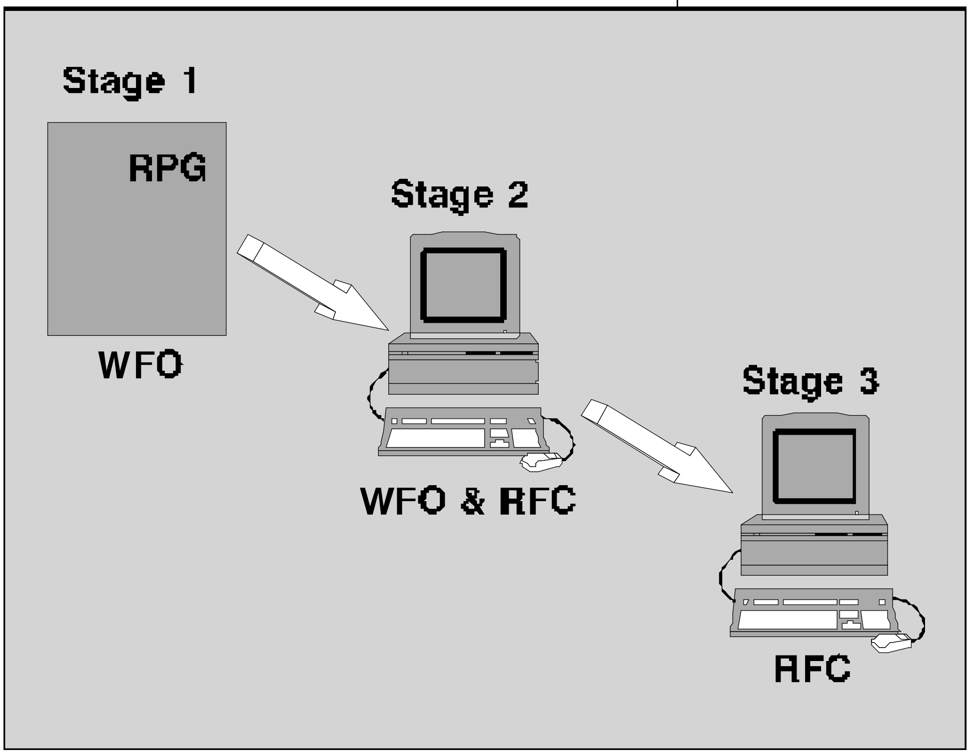


Figure 8-55. Downstream Precipitation Processing

At Stage II, the DPA data sent from each WSR-88D site undergoes additional automated quality control. For example, gridded satellite data will be used as a check for false precipitation estimates. For grids where radar estimates are nonzero, satellite data will be checked for the presence of clouds. Nonzero precipitation estimates identified in areas of no clouds will be removed. The result is a multi-sensor field - rainfall values built from radar estimates, gage reports, and satellite data.

Stage III

Each RFC can have 10 to 20+ WSR-88Ds within its area of responsibility, and the Stage II data from each site is mosaicked together to form one large data set of rainfall estimates for the entire RFC.

The quality control at this level is no longer automated. The forecaster compares the multi-sensor field to a comprehensive gage only field as a final check for false precipitation returns. Graphical programs allow the forecaster to quickly view suspicious rainfall reports. The forecaster has the option of removing suspicious rainfall from the multi-sensor field before inputting into the IFP.

See Supplementary Material 8-5-6 for additional information on Stage II and Stage III Processing.

Flash Flood

Flash Flooding

Defined as: A flood which follows within a few hours of heavy or excessive rainfall, dam or levee failure, or a sudden release of water impounded by an ice jam. (WSOM E-13)

Flash Flood Guidance(FFG)

Defined as: For a given time period, the rainfall amount that when exceeded, leads to small creeks, streams and drainage ditches exceeding their capacity.

Produced by one of 13 River Forecast Centers (RFCs)

- Zone FFG - assigned to forecast zones
- County FFG - assigned to individual counties
- Future FFG - assigned to grid boxes (1/40th LFM size, which is 2.2 nm x 2.2 nm)